New Scientist

WEEKLY 13 April 2024

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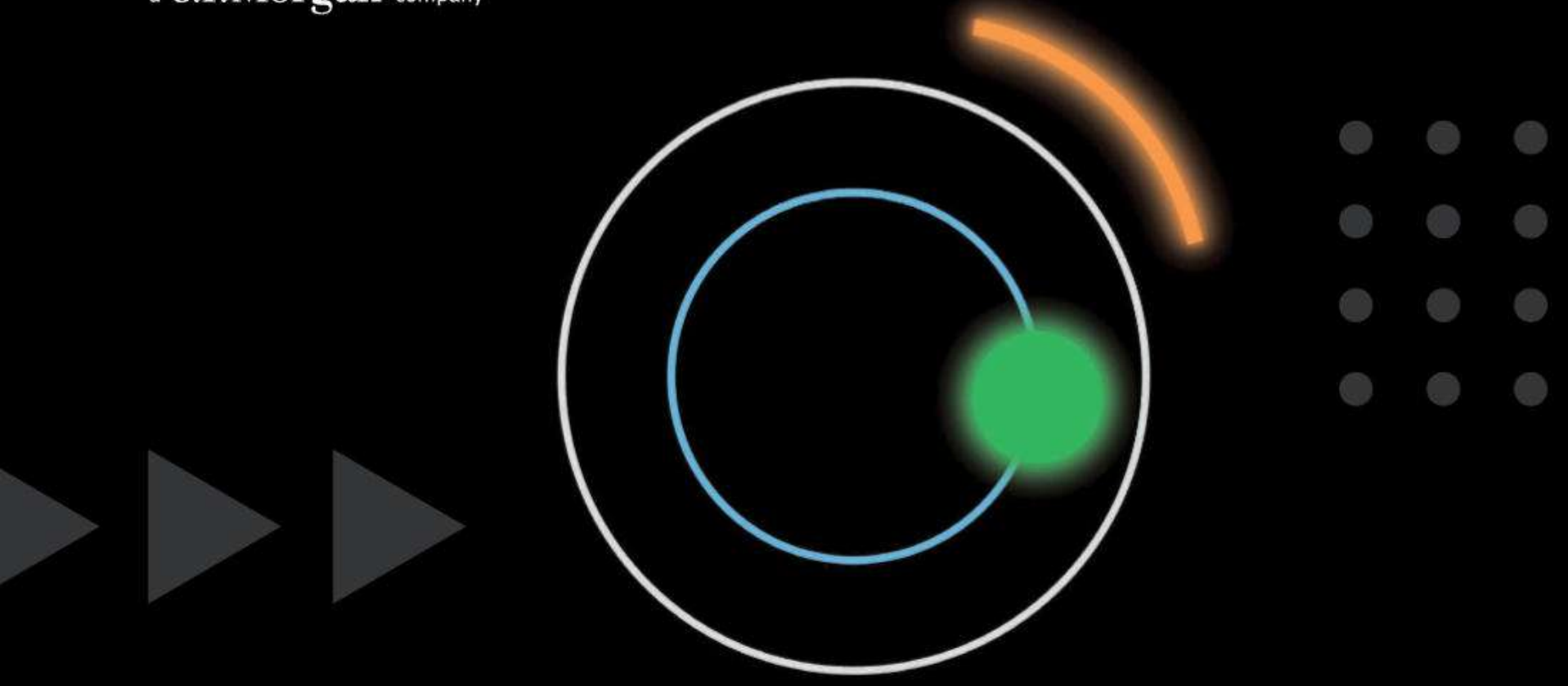

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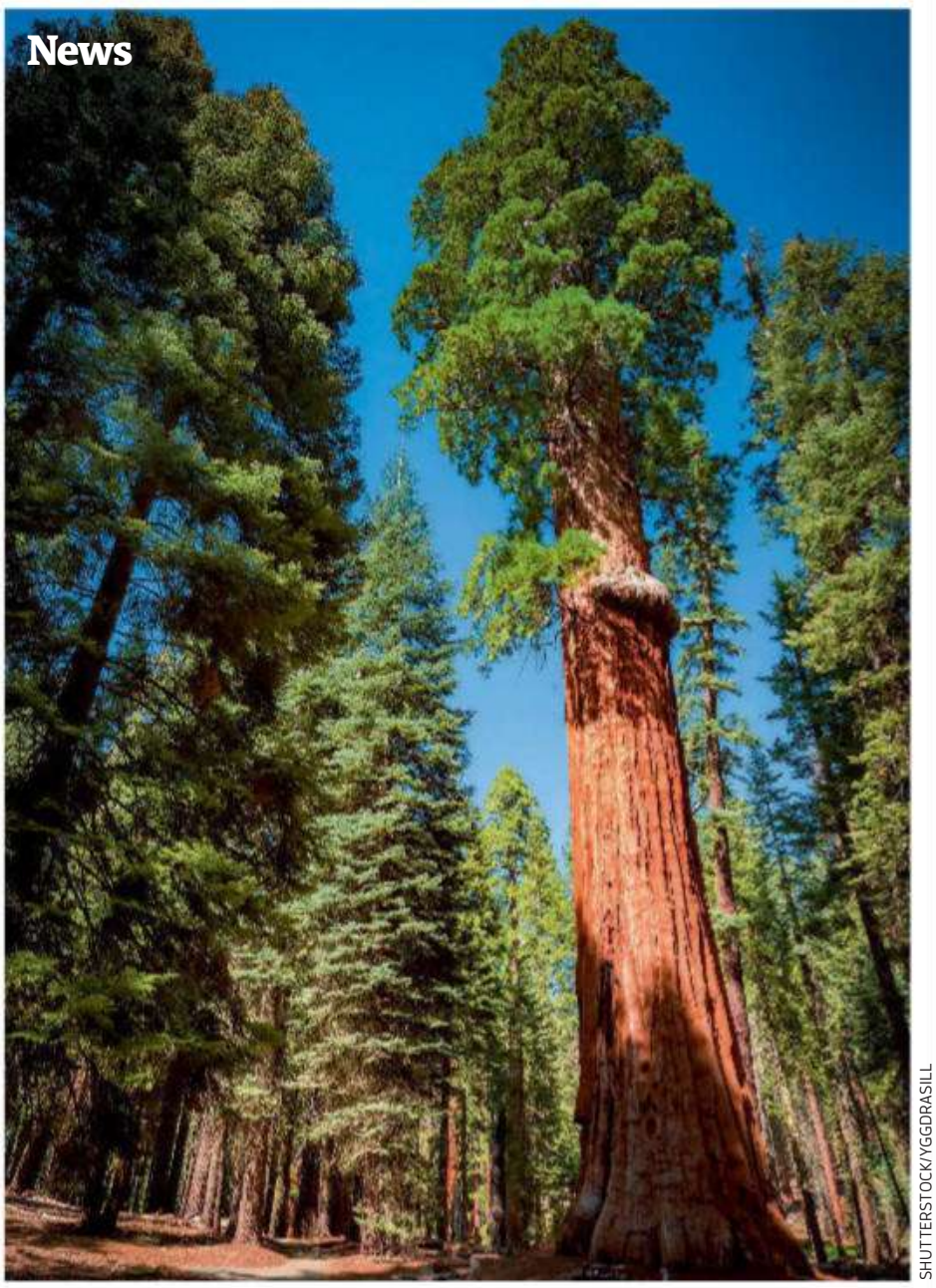

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Instant Expert

Decoding the cosmos

Giant space telescopes and particle detectors buried deep underground are revealing more than ever about the universe we call home. Join six leading experts on 15 June at London's Conway Hall to find out how we are reshaping our vision of the cosmos. Learn about the nature of dark matter, the search for life elsewhere, the mysteries of antimatter and the big bang.

newscientist.com/events

Tour

The birthplace of modern medicine

Join historian Helen Bynum as you journey around Paris, where the "Paris School" of hygiene and hospital teaching flourished, and Montpellier, home to the world's oldest university medical faculty. From mummified écorché figures to bone-lined catacombs, the history of medicine is sometimes gruesome but always incredible. This seven-day tour starts on 9 September and costs £3692.

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Podcast

Weekly

In this episode, the team discuss a mysterious GPS jamming attack in the Baltic region and introduce you to what may be the smallest galaxy in the universe. Hear how babies might start learning language while in the uterus and get up to date on an experimental therapy that transforms lymph nodes into miniature livers. Plus, snakes that can recognise their own scent.

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Puzzling galaxies Hear what to make of the latest cosmic mysteries

SAMANTHA OHLSEN/ALAMY

Catacombs in Paris Uncover the secret history of modern medicine

Video

Vanishing coral

Aerial surveys in the Great Barrier Reef Marine Park have recorded high or very high levels of coral bleaching in half of all its reefs. *New Scientist* reporter James Woodford went diving at One Tree Island, a remote, protected part of the reef system that has also now succumbed. Researchers are asking how much more of this the region's coral colonies can take.

youtube.com/newscientist

Newsletter

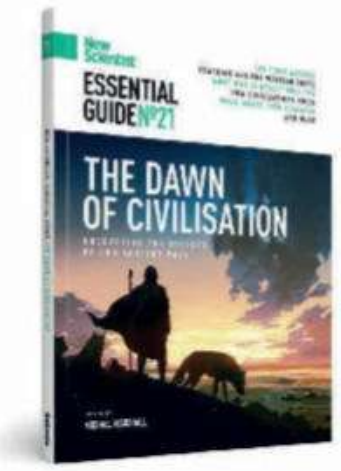
Our Human Story

It has been five years since *Homo luzonensis* was identified in a cave in the Philippines. Michael Marshall looks back on why the discovery of this new hominin species was so hard to piece together and re-examines what this 50,000-year-old specimen tells us about human evolution and the origin of our species.

newscientist.com/our-human-story

Newsletter

"Isolated on the island, *Homo luzonensis* evolved differently to other hominins"



Essential guide

Where are the origins of humanity? When did civilisation begin and what does the future of society hold? Uncover the secrets of the past in this *New Scientist Essential Guide* covering all that we know about the arc of human ingenuity. Now available to read in the app or buy in print from our online shop.

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Automated reasoning

Mathematical AIs show machine intelligence may emerge from unexpected pursuits

FOR Bill Gates, artificial intelligence is the most important invention since the internet or the personal computer. For Google boss Sundar Pichai, it will have a more profound impact than electricity and fire. Already, though, there are signs the AI revolution may be faltering. Since OpenAI released its landmark GPT-4 system in March 2023, new large language models like Google's Gemini have offered only incremental improvements.

GPT-5 could change this tomorrow, of course. But progress can also come from unexpected places, like the esoteric world of pure mathematics.

Although maths provides the foundations on which AI systems are built, professional mathematicians have been sceptical that AI could ever discover new conjectures, say, or construct tricky proofs. That is because research-level maths requires highly sophisticated reasoning and creativity. As we report in our story on page 32, however, AIs are beginning to pull off some remarkable mathematical feats, matching humans in elite competitions and contributing fresh insights to decades-old conundrums.

"Pure maths might seem an unlikely proving ground for generally intelligent AIs"

There are question marks around the extent to which these systems are approaching human-like reasoning, and whether their combination of a component that generates solutions and another that evaluates them tells us anything new about how to build more generally intelligent AIs.

In any case, computer scientists are excited. Seemingly simple architectures have yielded progress before. Google's Transformer model ushered in the current era of AI chatbots, for example. And it is possible that the reasoning and creativity we think of as uniquely human aren't as difficult to replicate as we imagine.

Pure maths might seem an unlikely proving ground for generally intelligent AIs. But the logic is that if these systems can tackle the hardest problems in maths, they might also be capable of generalising those abilities. That would herald machines that reason and think like humans, and justify prophecies of a revolutionary technology. ▮

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KENDALL RUST

Astronomy

North America's stunning eclipse

Millions of eyes turned to the sky on 8 April as a total solar eclipse passed over Mexico, the US and Canada. In the eclipse's path of totality, the moon's silhouette blocked out the entire disc of the sun, as is seen in this startling image taken in Jonesboro, Arkansas. Total solar eclipses provide a unique chance for scientists to view the sun's diaphanous outer layer, the corona.

Physics

Multiplying the multiverse

A new way of interpreting the elusive mathematics of quantum mechanics could fundamentally change our understanding of reality, finds **Karmela Padavic-Callaghan**

SHUTTERSTOCK/VCHAL

THE multiverse could be infinitely bigger than we ever imagined, according to a new interpretation of quantum mechanics that describes realms upon realms of parallel universes created with every decision we make.

At the heart of quantum mechanics is the wave function, an infamously abstract and

"Quantum theory is really well tested, but we'd like to understand how a classical world emerges from that"

fuzzy mathematical tool that is extremely good at describing the behaviour of photons, electrons and other denizens of the quantum realm. But what exactly is the wave function? After almost a century of arguments, physicists still disagree on how to make the leap from mathematics to the tangible, physical world.

In the most conventional view, known as the Copenhagen interpretation, the wave function mathematically describes all possible states of an object before it is "observed", an act that leaves it in an unambiguous state by "collapsing" the wave function.

For example, in the Schrödinger's cat thought experiment, a cat is placed in a box that will be flooded with poison gas when an atom decays. Because the behaviour of the atom is quantum mechanical, when the box is closed, the cat's wave function simultaneously contains both its alive and its dead states. When an observer opens the box, the wave function collapses and the cat is either dead or alive, with the other possibility vanishing. Its behaviour from then on is fully non-quantum, or classical. Once observed as dead, the cat doesn't come back to life.

Many worlds

A cat that is both living and dead may be hard to swallow, but another view of quantum mechanics created by physicist Hugh Everett in the 1950s has even more startling implications. In the many-worlds interpretation, the wave function doesn't collapse into only one certain, classical state, because each quantum state that it contains is already perfectly real – in one of many parallel worlds. When you open the box and observe a living cat, a replica of you in another world has just found it dead, with the act of observation effectively giving rise to two separate worlds.

The many-more-worlds interpretation enlarges the multiverse

Whichever view you favour, a big open question remains: how does this emergence of what we perceive to be classical behaviour apply to the whole universe?

"All the stars, galaxies, planets, life, they all start off as quantum fluctuations in the very, very early universe. As the universe expanded, eventually these things became classical," says Arsalan Adil at the University of California, Davis. "And quantum theory is really well tested, so we agree that it is, to some approximation, the correct theory, but we'd like to understand how a classical world emerges from that."

Who's watching?

One issue with both the Copenhagen and many-worlds interpretations is exactly what counts as an "observer", which is particularly a problem in the early universe when there was nothing and no one to make observations. To sidestep this, Adil and his colleagues began with the less anthropocentric idea of looking at collections of particles, with the behaviour of each particle determined by the way energy is structured across all particles in the system.

"We are big, warmish objects that are used to interacting with other big, warmish objects that are well localised in position, and we construct some scientific story based around these things. But you can kind of turn it the other way around and say that what the universe actually gives us in its most raw form, getting rid of our human perspective, is just some energy structure," says team member Zoe Holmes at the Swiss Federal Institute of Technology in Lausanne.

Freed of the need to consider distinct "observers", the team developed an algorithm that identifies ways to divide these systems of particles into subsystems. Any subsystem is considered a valid view of the world, as long as the interactions between subsystems lead to one of them becoming classical – essentially a much more general version of opening the box in Schrödinger's thought experiment. "You can have part of the Earth and the Andromeda galaxy in one subsystem, that's a perfectly legitimate

subsystem," says Arsalan.

This new perspective uncovered myriad realms of new worlds, beyond the simple dead-and-alive ones, leading the researchers to call it the many-more-worlds interpretation. To understand why, consider a quantum version of deciding whether to have coffee or tea at breakfast. In the Copenhagen interpretation, you make a decision and the wave function collapses. If you then decide between eating toast or cereal, a second wave function collapses. All of this takes place within the only universe that exists.

But in the many-worlds interpretation, the you who is craving coffee and the you who prefers tea both exist in parallel worlds, and each of those worlds will again branch into two depending on what you decide to eat (see "A quantum point of view", below).

In the many-more-worlds interpretation, the interaction between you and your breakfast

"We have had so many arguments over this, we have tied ourselves in circles"

gives rise to one realm made up of many worlds, but more realms of worlds arise from less intuitive divisions of your world into subsystems like your cup and some faraway celestial object, or an even more odd designation of your left arm to one subsystem and your right to another. With many more perspectives, each giving rise to a realm of new worlds, the net effect is enlarging the already vast multiverse of Everett's interpretation (arXiv, doi.org/mqcx).

Paolo Zanardi at the University of Southern California Dornsife says that the new interpretation achieves "a sort of operational democratisation" between the ways of segmenting reality, as it doesn't forbid any subsystem splits just because they are odd or counterintuitive, which he finds compelling and satisfying. But the algorithm the researchers use to find the various subsystems' divisions still contains some assumptions, like how long it takes for a subsystem to become classical, so there is room for more mathematical exploration and refining of the idea, he says.

"This is a good, serious, useful contribution to the growing literature on how to take a 'bare bones' quantum mechanical theory and extract from it something resembling the classical world of our experience," says Sean Carroll at Johns Hopkins University in Maryland.

Unresolved issues

Carroll has also looked at dividing quantum systems into subsystems, but he has found that valid subsystems that lead to appropriately classical worlds are rarer than the multitude of realms suggested by Adil, Holmes and their colleagues. This may be because there are different ways to quantify when exactly a system is non-quantum enough to be considered classical, he says.

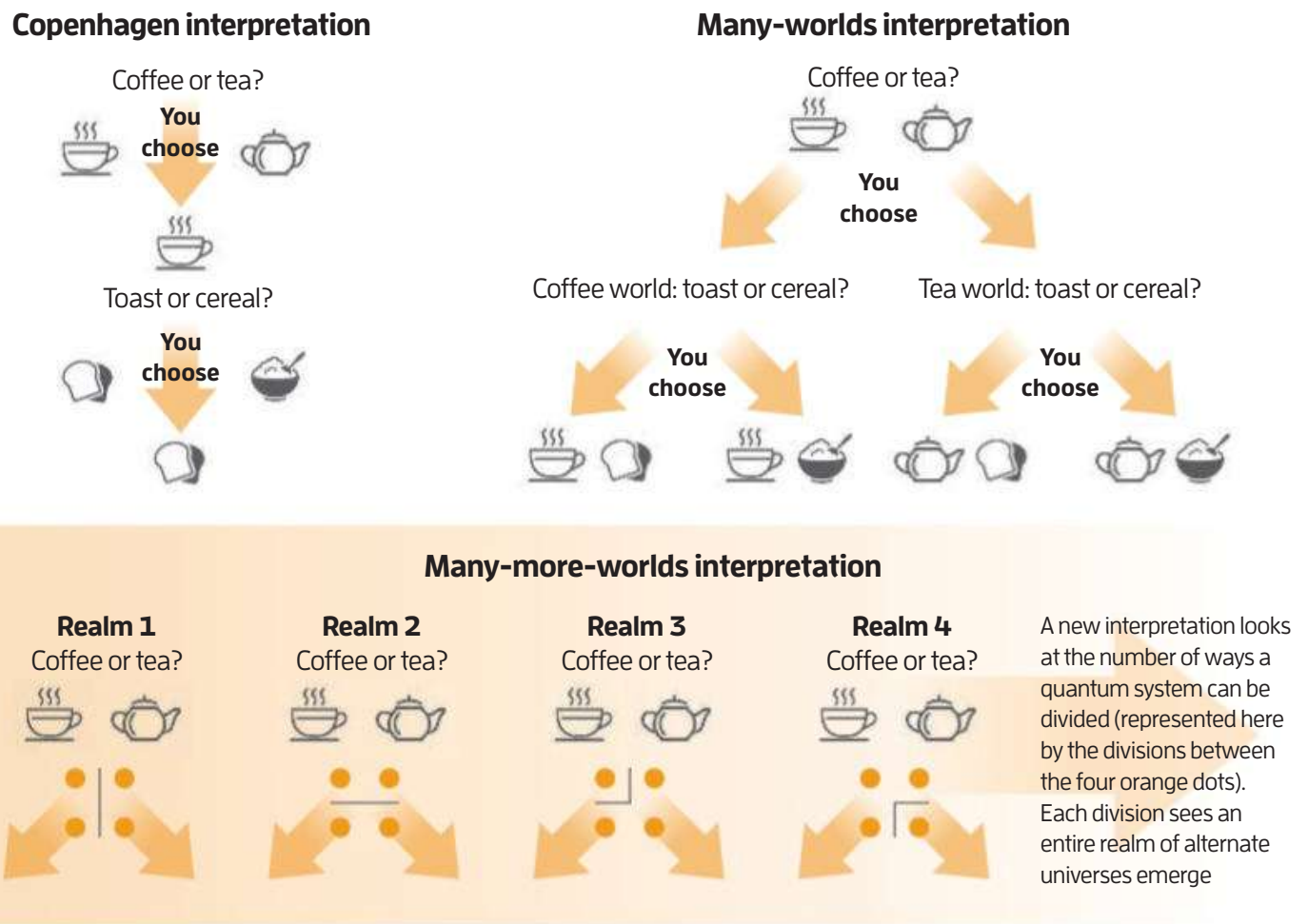
While those questions remain to be resolved, exactly what an enlarged multiverse might mean for our understanding of reality is still unclear, even for the team. Adil says he and his colleagues are currently "agnostic about the ontological conclusions" of what they have uncovered so far. Holmes says that when she is feeling sceptical, she worries that their work is akin to finding shapes in the clouds, rather than a reflection of reality.

Yet both researchers can't shake the feeling that they have come across something meaningful and want to pursue it further.

"I would say I think we know this is true, but we don't know whether it's important," says Holmes. "We have had so many arguments over this, we've tied ourselves in circles." ▮

A quantum point of view

Different interpretations of quantum physics have startling conclusions, from observers influencing reality to a proliferation of alternate universes



A new interpretation looks at the number of ways a quantum system can be divided (represented here by the divisions between the four orange dots). Each division sees an entire realm of alternate universes emerge

Analysis Bird flu

Is another pandemic on the way? The first case of H5N1 bird flu passing from cows to humans should spark expert investigation, but not general panic, says Grace Wade

NEWS of a bird flu virus infecting dairy cows across the US and a person exposed to the animals may raise concerns, but experts say we shouldn't worry about another pandemic yet.

"At this point in time, I would not think a pandemic is likely," says Jodie Guest at Emory University in Atlanta, Georgia. "The risk to humans is quite low. It's not nothing, but it is very, very low."

Since 2021, a subtype of the bird flu virus, H5N1, has devastated global bird populations. It has also infected an increasing number of mammals, including foxes, seals, mink and, most recently, cows.

In late March, dairy cows across Texas, Kansas, Michigan, New Mexico and Idaho tested positive for the virus. A person also contracted it after interacting with the cows – the first known case of H5N1 jumping to humans from another mammal.

The individual's only symptom is eye redness, and they are recovering, according to the US Centers for Disease Control and Prevention (CDC).

But bird flu can be deadly. Around half of the 887 people confirmed to have been infected with H5N1 since 2003 have died from the virus. "Any case of H5N1 is concerning because it is highly dangerous to humans," said Tedros Adhanom Ghebreyesus, director-general of the World Health Organization (WHO) on 3 April.

The good news is the virus hasn't been transmitted between people. Plus, initial testing of samples from the infected person and cows don't show mutations that would significantly increase that risk, according to the CDC. "This particular virus is still very much a bird virus," says Richard Webby at St. Jude Children's Hospital in Tennessee.

Yet he says each time the virus infects or transmits between mammals, it could acquire mutations that may make it more dangerous to humans. That is why the WHO says it is working closely with the CDC to track the virus. The US Department of Agriculture has also stepped up surveillance efforts.

887
People with confirmed H5N1 infections since 2003

ARTERRA/IMAGEBROKER/SHUTTERSTOCK

Dairy cows across the US have tested positive for bird flu

One unknown is whether the virus is spreading between cows. Evidence suggests that is the case, says Fred Gingrich at the American Association of Bovine Practitioners (AABP) in Ohio. For instance, cows in Michigan became ill after those from a herd in Texas were introduced to the farm. "Probably our biggest question is how it is transmitted between cows," says Gingrich.

Genetic sequencing will help trace the virus's spread, says Meghan Davis at Johns Hopkins University in Maryland, but this will take time. In the interim, the AABP is advising dairy farmers to provide workers with masks, gloves and other protective equipment to prevent the virus's spread. People should also avoid raw milk and raw milk products, which can transmit the virus. Otherwise, the general public's risk is low.

"If you're an average consumer and you're drinking pasteurised milk, don't panic. Be aware, but don't panic," says Davis. ▮

Technology

A simple way to fix stereotyped AI images

AI image generators can be made more culturally sensitive and accurate by feeding them just a small number of more representitive images.

The images used to train these artificial intelligence systems "are mostly about the Western world", says Jean Oh at Carnegie Mellon University in Pennsylvania, and so can often misrepresent or stereotype non-Western cultures.

Oh and her colleagues asked people living in underrepresented countries to provide captioned images that better reflect their society, receiving around 1000 in total from people in China, South Korea, India, Mexico and Nigeria.

The team showed these images to a pre-trained version of Stable Diffusion, a widely used image generating AI model, presenting them as accurate cultural representations, while flagging images generated by the model that were stereotyped – a method called self-contrastive fine-tuning.

To judge the effect of the fine-tuning, 51 people from the five countries reviewed outputs from both the retrained and original models. On average, the fine-tuned model was perceived to produce less offensive images between 56 and 63 per cent of the time. Stability AI, the company that created Stable Diffusion, did not respond to a request for comment.

Feeding the model a small number of additional images – Stable Diffusion was reportedly trained on 2.3 billion images – seems to successfully remove reliance on stereotypes, suggesting this form of AI bias can be countered comparatively cheaply and simply (arxiv, doi.org/mqgf).

"The images used to train artificial intelligence systems are mostly about the Western world"

"This is a great approach," says Rumman Chowdhury at Humane Intelligence, a non-profit that reviews AI models, though she points out that the issue isn't always that AI models lack diversity, but that they don't understand what that is – or when it is appropriate and important to consider it. ▮

Chris Stokel-Walker

Astrophysics

Cosmic expansion mystery solved?

The rate at which the universe is expanding has been one of the most controversial numbers in cosmology for years, but we may finally have a resolution, finds **Leah Crane**

A COSMIC mystery that is one of the most significant open questions in physics may finally have been solved. The two main methods of measuring the universe's rate of expansion have long been in disagreement with one another – but they seem to be coming together.

The rate of the universe's expansion is measured by a parameter called the Hubble constant. For years, the two ways we work it out have been in tension, which led some cosmologists to believe that we didn't understand something fundamental about the universe – perhaps the nature of dark energy or an unknown field.

The first way of measuring the Hubble constant is based on tiny fluctuations in the cosmic microwave background (CMB), the relic light left over from the big bang. These fluctuations can be used alongside our best model of the cosmos to calculate the expected current rate of the universe's expansion. The CMB method gives a Hubble constant of 67 kilometres per second per megaparsec, suggesting the rate of expansion increases by 67 km/sec for every megaparsec of distance from Earth (1 megaparsec is about 3.26 million light years).

The other method is called the local distance ladder. It involves using objects at different distances from Earth – different "rungs" of the ladder – to measure the expansion of the area of space that is relatively near to us. The ladder's two main rungs have generally been Cepheid stars and type Ia supernovae, each of which have extremely reliable absolute luminosities that we can compare with their apparent brightness to determine how far away they are. The local distance ladder has long yielded a Hubble constant of about 73 km/sec/Mpc. The difference between the two measurements is called the Hubble tension.

"My big concern in the distance scale was that when you only have one method, you have no way to tell what the systematic uncertainties are in that method," says Wendy Freedman at the University of Chicago.

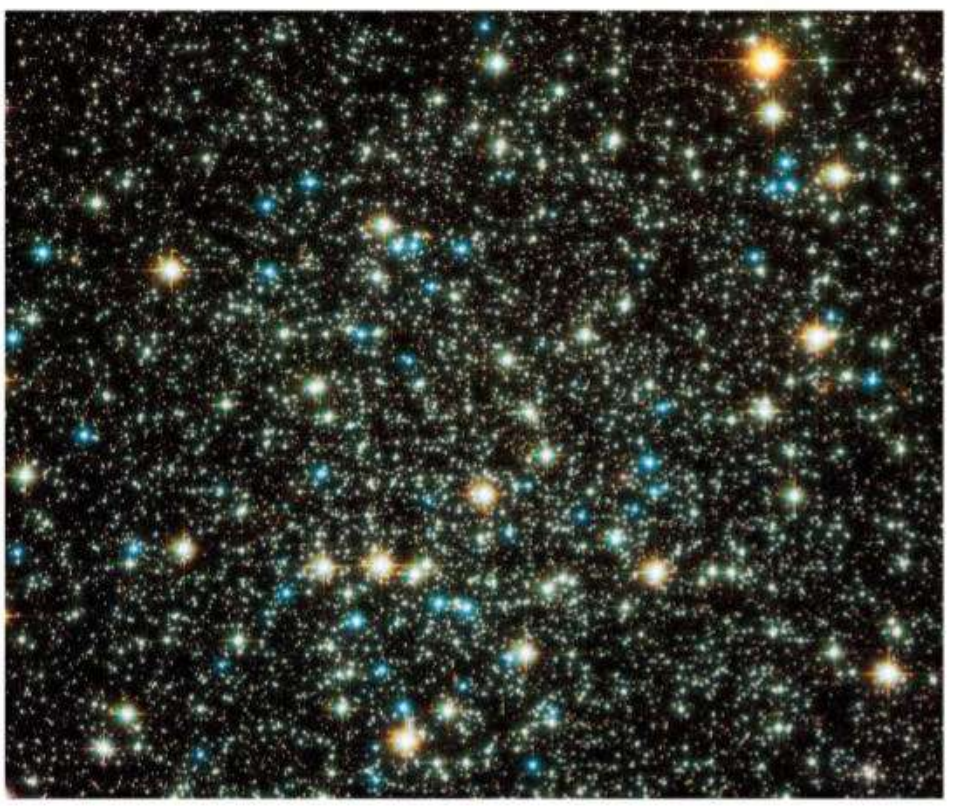
"The difference between a Hubble constant of 73 and 69 is small, but these things are really important"

Freedman and her colleagues have used the James Webb Space Telescope (JWST) to add two more methods to the local distance ladder. They observed two other types of stars – carbon stars and so-called tip of the red giant branch stars – each of which have predictable luminosities based on their mass. They also observed more Cepheids with the high resolution of JWST as well as reanalysing all the archival data from the Hubble Space Telescope previously used in local distance ladder measurements.

Using this more precise distance ladder, they calculated a Hubble constant of about 69 km/sec/Mpc, which is consistent with the CMB measurements. "The difference between a Hubble constant of 73 and 69 is small, but these things are really important to get right," says Freedman.

She presented this work at a meeting of the American Physical Society in California on 6 April. "These much more precise data are not screaming out saying you really need new physics," she says. "We are finally converging now – it's really exciting."

Not all cosmologists agree that the problem is on its way to being resolved. "If the Hubble tension disappears, that would be very important. It would mean our 'end-to-end' test of cosmology passes finally," says Daniel Scolnic at Duke University in North Carolina. "However... this doesn't feel like the current state we are in." He points out that the number of galaxies observed with JWST is relatively small and other groups have come up with a higher figure for the Hubble constant based on JWST data, rather than the lower one Freedman's team found.



ESA/HUBBLE & NASA

The further galaxies are from Earth, the faster they are moving away from us

Getting close

Adam Riess at Johns Hopkins University in Maryland, the head of one of those groups, is also sceptical. "I do not believe the Hubble tension has changed, but I do know there is a difference in the way we are analysing supernovae... one that produces a difference in the Hubble constant," he says. "I don't think it would be fair or accurate to define the size of the tension from the lowest (or highest) measure."

The numbers are becoming very close, says Rocky Kolb at the University of Chicago. "I suspect that one group is underestimating their errors... I do not feel there is a viable explanation to resolve the tension, if it exists."

The fact remains that it is hard to reconcile current cosmological models with the higher Hubble constant found in previous local distance ladder measurements, says Lloyd Knox at the University of California, Davis. "[These new results] looked to me like a big step toward this resolution," he says.

Freedman and her colleagues are still calculating the uncertainties of their measurement. For now, although it leans towards matching the CMB Hubble constant, it isn't inconsistent with previous local measurements. It will take more attempts with more methods to put the Hubble tension to bed, says Freedman. "Is this the end of the tension? Nothing dies that simply," she says. "But these data are pointing the way."

Animal behaviour

Left-handed monkeys prompt an evolutionary rethink

Christa Lesté-Lasserre

MONKEYS in India that adopted an urban life are mostly left-handed, in contrast to humans and many other primates that live on the ground.

The findings clash with long-standing claims that primates that come down from the trees generally evolve a tendency to be right-handed, raising questions about what really drives this trait.

The Hanuman langurs (*Semnopithecus entellus*) – named in honour of the monkey-like Hindu deity Hanuman – gave up their homes in the trees at least 165 years ago and now often live off food offerings from people who regard them as sacred.

CYRIL RUOSO/MINDEN PICTURES/ALAMY

Hanuman langurs mainly live on food offerings from people

"Hanumans have a high amount of deity value among the Indians, irrespective of religion," says Akash Dutta at the University of Calcutta in India. Only 9 per cent of the animals' natural habitat remains following massive expansion of human settlements, he adds.

Seeing that the monkeys' behaviours and actions have been evolving, Dutta decided to investigate their laterality, or handedness. He wondered how they fit into what is known as the postural origin theory.

This much-debated concept suggests that the earliest branches of primates lived in trees and were left-handed, using their left hand to grab food or branches while holding onto the tree with their right.

Those that later adapted to life on the ground – like humans, 90 per cent of whom are right-handed – switched to having a predominantly right-sided laterality, as they could now use their free right hand to handle tools and other objects. This stimulated the motor skills region in the left side of the brain, which controls the right side of the body – in turn promoting more use of the right hand.

Studies show that chimpanzees, gorillas, baboons, bonobos and ring-tailed lemurs are mostly right-handed, for example, whereas Sichuan snub-nosed monkeys, deBrazza's monkeys and orangutans – all of which live in trees – are mostly left-handed.

To test the postural origin theory in a group that had recently transitioned out of the trees, Dutta and his colleagues carried out 193 laterality tests on 35 free-ranging Hanuman langurs. The monkeys included males and females, both juvenile and adults.

The researchers handed each monkey a sweet bun trapped inside an open, transparent bottle. Only 27 per cent of the monkeys showed right-handedness in getting the bun out of the bottle. Fifty-three per cent were left-handed, and the rest were ambidextrous or tried using their mouths to extract the bun (*Animal Behaviour*, doi.org/mqts).

The results surprised Dutta. He thinks the monkeys' DNA still programs for left-handedness, even after dozens of generations in their new environment. "The ancestral tendency is still there," he says. He predicts that the urban langurs will shift to right-handedness over time.

However, Kai Caspar at Heinrich Heine University Düsseldorf in Germany says the study provides further evidence that the tree-related idea for the evolution of handedness is wrong. "I frankly don't understand why it still maintains its high status in the research community," he says. For Caspar, the explanation for handedness has yet to be uncovered. ▮

Technology

Phone batteries could last longer with more 5G masts

Matthew Sparkes

INCREASING the number of 5G phone masts could slash a mobile network's overall energy use by two-thirds and extend the battery life of smartphones by 50 per cent.

Mobile phone signals are broadcast from towers in all directions, so a lot of the energy is wasted due to absorption, reflection and scattering. Agrim Gupta and his colleagues at the University of California, San Diego, have now used open-source software to simulate transmissions from base stations to smartphones and tested various configurations of networks on 3D models of real cities. Their aim was to maintain good coverage while minimising energy use.

Gupta says that increasing the number of masts was proposed in the 4G era, but this technology couldn't seamlessly switch a moving user's phone from tower to tower fast enough – something that would be required more often in a denser network. This has been addressed with 5G technology, he says.

"If you do this, there are significant improvements and efficiencies," says Gupta. "Your [phone] battery lifetime could be 50 per cent more. So if your battery was lasting 12 hours, it will last 18 hours now, because of this network."

50%

Phone batteries could last this much longer if there were more 5G towers

The sweet spot occurs when base stations are, on average, five times closer to mobile phones than today (arXiv, doi.org/mqvm). Gupta says the cost of building new towers is still a hurdle, but lower energy use would offset this. Having towers closer together would also mean they could be shorter, as they would no longer need to be tall enough to allow signals to pass over obstacles, cutting construction costs, he says. ▮

Is there a better way to screen for prostate cancer?

Inaccurate blood test results can lead to unnecessary treatment, but new proposals could address this, says **Clare Wilson**

THERE is both good news and bad news about prostate cancer screening. First, the bad news: the blood test involved, which measures a compound called prostate-specific antigen (PSA), is too inaccurate. As a result, some men end up having cancer treatments they didn't really need.

On the other hand, combining a PSA test with an MRI scan of the prostate would make screening more accurate, especially if the dual test were recommended only for those at high risk of the tumour. A group of experts has made this recommendation in a new report (*The Lancet*, doi.org/mqjg).

Prostate screening has long been controversial. Although PSA is released at high levels by cancerous prostate cells, it is produced at lower levels by healthy ones too.

The blood test was introduced as a way to track the success of cancer treatment. It started being used as a screening test in the 1990s, partly as a result of campaigns by men's health groups.

The problem is that a PSA check alone is an unreliable screening tool. Levels can become temporarily raised after sex, or merely a bike ride. Even if the rise is persistent, most prostate cancers grow so slowly that, if left alone, they would never have been noticed.

These issues would matter less were it not for the fact that the treatments to destroy the cancer – usually surgery or radioactive pellets put into the tumour – can often cause permanent incontinence or erectile dysfunction. Even a biopsy to find out if cancer is present can result in these problems.

Randomised trials show that, for every 1000 men who take up regular PSA screening, there is one fewer death from prostate cancer over 10 years, but three men are left with incontinence and 25 with impotence.

These uncomfortable figures have left health services in most high-income countries, including the UK and Australia, with an uneasy compromise. They don't send invitations for prostate screening – unlike with breast or bowel cancer checks – but people who ask for the test can have one provided the risks are explained.

"Treatments to destroy the cancer can often cause incontinence or erectile dysfunction"

The upshot is that PSA tests are taken up more by men with higher incomes and less by those with lower incomes or who are Black, says the new report. This is unfortunate because men of African heritage are about twice as likely to get prostate cancer as men with European heritage.

The Lancet Commission on Prostate Cancer, which produced the new report, says health systems should use a more sophisticated form of screening, involving both a PSA test and an MRI scan. The scan lets doctors assess the prostate's size and spot any suspicious areas that might indicate a cancer.

The commission says health services should begin formal screening campaigns using this combined method, but target three groups that are known to be at higher risk. These are: Black men, anyone with a family history of prostate cancer and men with mutations in one of the *BRCA* genes, which are also associated with breast cancer.

This would avoid the current situation where men with lower risk levels are arguably getting too many PSA tests, while those at higher risk get fewer or none at all. ▮

Ecology

Suppressing wildfires is harming giant sequoia trees

SHUTTERSTOCK/ERIN DONALSON

Giant sequoias in California rely on heat to disperse their seeds

THE controlled burning of dry areas to limit the damage from wildfires in California seems to be hurting the state's iconic sequoia trees.

Giant sequoias (*Sequoiadendron giganteum*), also known as giant redwoods, have been dying off since the early 1900s. These trees benefit from fires because they rely on high heat for seed dispersal.

Many Californian communities are in fire-prone areas, which can lead to devastating results if risks aren't managed. That is why controlled burns, intended to remove dead trees that act as fuel for wildfires, are done.

Now, Chad Hanson at the John Muir Project, a non-profit group that works to protect public forests, and his colleagues have studied Nelder Grove in the Sierra National Forest, which hosts about 65 mature sequoias. The trees were hit hard by the 2017 Railroad Fire, but now a new generation of sequoias is growing. In 2023, the researchers entered the burn zones and measured post-fire sequoia reproduction, heights of sequoia saplings, shrub cover and distance to the nearest live, cone-bearing sequoias in 23 plots (*Ecology & Evolution*, doi.org/mqtr).

"We found giant sequoia reproduction was the densest, tallest and most dominant, relative to other conifers, in the high-intensity fire patches," says Hanson.

The presence of the trees may also have benefits for fire prevention. "Wildfires spread more slowly and often less intensely through denser forests with more biomass and more vegetation because those areas have a cooler, shadier, more moist microclimate," he says.

Commercial logging by the National Park Service and US Forest Service, intended to thin trees, can prevent sequoias from reproducing, says Hanson. He says we can strike a balance to save trees and protect people living near them by pruning vegetation within 30 to 60 metres around homes. ▮

Adam Popescu

Environment

Green sand could help shallow seas absorb more carbon dioxide

Alec Luhn

DUMPING alkaline green sand into shallow seas could increase ocean absorption of carbon dioxide by 8 per cent this century, according to a modelling study.

Oceans take up almost a third of the CO_2 we emit into the atmosphere and researchers are exploring ways to boost that amount. Andrew Yool and Julien Palmiéri at the UK's National Oceanography Centre have found that dissolving 1 gigatonne a year of ground-up olivine – a common, greenish mineral made mainly of magnesium, iron, silicon and oxygen – in shallow seas could reduce atmospheric CO_2 levels by 10 parts per million (ppm) by 2100. This would lower Earth's average temperature by 0.06°C, they estimate (*Earth's Future*, doi.org/mqtw).

Atmospheric CO_2 is at 423 ppm now and would reach 1200 ppm by 2100 in the high-emissions scenario the pair modelled. But the study suggests that if we cut emissions from most sectors, olivine deployment in a few key locations could help compensate for sectors like steel-making or air travel that are hard to decarbonise, says Yool.

"It's doable. [Olivine] works at a kind of a scale approximately similar to what you could realistically mine," he says, adding that it could help the world achieve net zero.

The idea is to speed up the natural weathering of rocks by the sea. Olivine would react with water to form bicarbonate (HCO_3), turning seas more alkaline. That allows more CO_2, a weak acid, to dissolve in the water.

A 2023 study found that olivine sand deployed across the oceans would mostly sink into the depths before it could raise pH. Yool and Palmiéri modelled an alternative scenario, in which olivine is spread over coastal shelves less than 100 metres deep to keep it close to the surface. The pair found that currents would redistribute the more alkaline water, with half of atmospheric CO_2 absorption happening off the shelves.

MICHELE AND TOM GRIMM/ALAMY

Olivine sand from Papakōlea Beach on Hawaii's Big Island

> **"Could you actually practically do this? And what would the ecosystem impacts be?"**

Alkalinity would increase most in shallow, warm seas like the Yellow Sea, Gulf of Mexico and Persian Gulf and around the Indonesian and Malaysian archipelagos. "Those would be regions where I would be starting to think: what are they like ecologically and would they be able to tolerate this sort of perturbation?" says Yool.

The ecological impact of alkalinity enhancement was flagged as a concern by the 2023 study. It found that olivine sand may harm zooplankton, so could disrupt food chains.

In 2022, magnesium hydroxide was added to waste water flowing into the sea in Cornwall, UK as a trial of alkalinity enhancement. The firm behind the test, Planetary Technologies, is seeking approval to carry out a larger trial, despite local opposition.

While overall ocean alkalinity would change little after the additional CO_2 is absorbed, we don't fully know if discharging magnesium hydroxide would harm organisms near the waste water pipe, or if adding olivine would smother organisms on the seafloor, says Paul Halloran at the University of Exeter, UK.

Yool and Palmiéri's study shows that it is theoretically possible to remove a significant amount of CO_2, says Halloran. "But the open questions are really, could you actually practically do this? And what would the ecosystem impacts be?" ▮

Space flight

Satellite licence plates could help avoid collisions

Alex Wilkins

EQUIPPING satellites with laser-activated licence plates could prevent collisions in space, even if the craft lose power.

The number of satellites has rocketed in recent years thanks to the likes of SpaceX's Starlink internet service, which accounts for around 60 per cent of the almost 10,000 satellites orbiting today. Many satellites identify themselves by broadcasting signals, but this can fail when satellites are close together, such as when they have just been launched on the same rocket.

Now, Fabrizio Silvestri at the Netherlands Organisation for Applied Scientific Research and his colleagues have developed a satellite-tracking system that uses small cubic mirrors. Each mirror is equipped with light filters that reflect laser light in a unique way, serving as a licence plate. By firing a laser at the mirrors from Earth and analysing the light reflected back, operators on the ground can identify the satellite in question.

Silvestri and his team tested the system on Earth over a distance of 2.43 kilometres. They used four different combinations of light filters to create five licence plates. "We could clearly see that there was a distinction between one combination and the other," says Silvestri, even when the laser was fired at different angles (*Communications Engineering*, doi.org/mqct).

Operating the system in space would mean accounting for the impact of atmospheric turbulence on the laser, but that shouldn't be too difficult, says Silvestri. It could also help track dead satellites that have become space debris, he says. While many existing satellite-tracking systems require an onboard power supply, the reflectors would passively respond to lasers from Earth. ▮

Technology

Quantum tech gets more reliable

Microsoft and Quantinuum may have created the most dependable device yet

Karmela Padavic-Callaghan

MICROSOFT and computing firm Quantinuum claim to have made a quantum computer that has an unprecedented level of reliability. Its ability to correct its own errors could be a step towards more practical quantum computers.

"What we did here gives me goosebumps. We have shown that error correction is repeatable, it is working and it is reliable," says Krysta Svore at Microsoft.

Experts have long anticipated the arrival of practical quantum computers, which could complete calculations that are too complex for conventional ones. Though quantum computers are becoming larger and more complex, this prediction hasn't yet been fully realised. One big reason for this is that all contemporary quantum computers make errors, and researchers have found it technically difficult to implement algorithms to catch and correct them during computation.

The team hasn't shared all the details of the work yet, but if confirmed, it would be a significant step towards overcoming this error problem – the researchers say they ran over 14,000 separate computational routines on Quantinuum's H2 quantum processors without a single error.

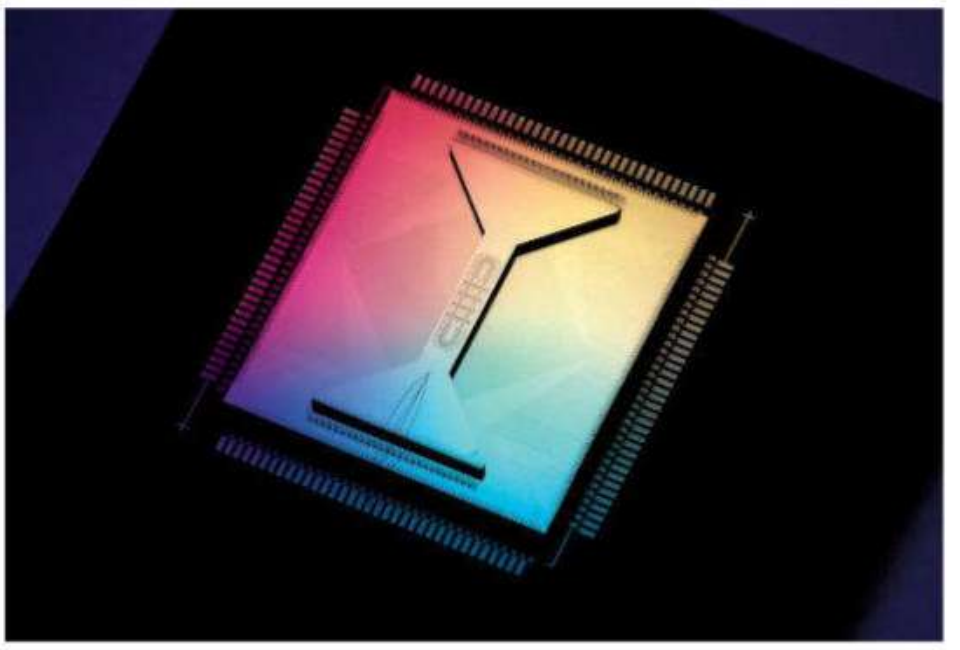
Classical computers also make errors, but error correction can be coded into programs by creating back-up copies of the information being processed. This approach isn't possible in quantum computing because quantum information cannot be copied. So, instead, researchers spread it across groups of connected quantum bits, or qubits, to create what are known as logical qubits. The Microsoft and Quantinuum team used 30 qubits to make four of these logical qubits.

Svore says that it was the generation of these logical qubits, using a process developed by Microsoft, that enabled repeated runs of error-free, or fault-tolerant, experiments. Individual qubits are typically easily disturbed, but at the level of the logical qubits, the researchers could repeatedly detect and correct the errors.

They say this approach was so successful that the four logical qubits produced as few as 0.125 per cent of the errors that were seen when the 30 qubits were left ungrouped. This means the ungrouped qubits would have produced as many as 800 errors for every one error produced by the logical qubits.

Mark Saffman at the University of Wisconsin calls this a "very significant advance" that "takes us another step closer to fault-tolerant quantum computing". But some experts consulted by *New Scientist* wouldn't qualify the work as a breakthrough without more details on the experiment.

It is generally accepted that only quantum computers with 100 or more logical qubits will be able to tackle scientifically and societally relevant problems in areas including chemistry or materials science. The next challenge is making everything larger. ▮



QUANTINUUM

The chip from Quantinuum's H2 quantum processors

Space

Gravitational 'tidal storm' makes planet glow red hot

A DISTANT world is being stretched by the gravity of its neighbouring planets and star to extremes never seen before in a rocky planet. The distortion is so intense that its surface is probably molten and so hot that it glows.

Stephen Kane at the University of California, Riverside, and his colleagues spotted this planet in a system already known to have one larger world, a giant planet circling the star once every 55 days or so. The star, called HD 104067, is about 66 light years from Earth.

The researchers found a second planet, a Uranus-mass world orbiting the star every 14 days or so, using a technique called the radial velocity method, in which the gravitational pull of a planet on its star produces characteristic wiggles in the star's light. Then, they spotted a possible third planet, this one only about 30 per cent larger than Earth, by looking for dips in the star's light as the planet passed between it and our telescopes. These dips showed that the third planet, TOI-6713.01, takes only about 2.2 Earth days to circle the star (arXiv, doi.org/mqgw).

ESA/HUBBLE, M. KORNMESSER

The surface of the newly discovered planet is probably entirely molten

The two larger planets seem to have relatively eccentric orbits, following oval-shaped trajectories that whip in close to the star and then drift to the outer reaches of the stellar system. The gravitational pull of these worlds drags the smaller rocky planet into an eccentric orbit too, fighting with the pull of the star.

This combination of the gravity from the outer planets and the star creates what Kane describes as a "perfect tidal storm", pulling on the inner world, stretching it like clay.

Flexing of the planet's innards as it changes shape then produces extraordinary amounts of heat. "The temperature of this planet is hotter than some stars," says Kane.

If we can determine the planet's mass, it should uncover its geology, shape and surface conditions. ▮

Leah Crane

Field notes One Tree Island, Australia

Great Barrier Reef pushed to the brink

Even remote areas previously shielded from mass bleaching are now being overwhelmed by extreme temperatures, finds **James Woodford**

ONE Tree Island isn't an easy place to get to. Part of the Great Barrier Reef, there is often just one short window each day when the tides are high enough for a small boat to cross the rampart of treacherous coral that surrounds the island. Only then can you reach the remote research station it houses.

I was travelling with Selina Ward from the University of Queensland in Brisbane. Like me, she was making the arduous trip to the island, found 100 kilometres off the Australian mainland, to investigate the scale of a mass coral bleaching event unfolding in the waters around the highly protected coral cay.

When water temperatures are higher than normal, corals eject the algae that live inside their tissues and provide them with food, putting them at risk of starvation and death.

In the weeks leading up to our visit, the water temperature in the region around the island had reached the mid-30s in Celsius (mid-90s in Fahrenheit) – the recommended warmth for a spa hot tub. Researchers were only able to work underwater for half an hour before feeling like they, too, were cooking.

The same story was unfolding up and down the 2300-kilometre-long Great Barrier Reef. Last week, the Great Barrier Reef Marine Park Authority and the Australian Institute of Marine Science concluded aerial surveys of 1000 reefs. Half recorded high or very high levels of coral bleaching, and high to extreme levels of bleaching were common in the southern region of the marine park, where One Tree Island is located.

The good news is that the marine heatwave appears to have peaked and the waters throughout the reef have begun to cool, but they are still much warmer than the long-term average. Now, researchers are set to assess the longer-term damage.

Bleaching isn't necessarily lethal, but if the water doesn't cool quickly enough in the coming weeks, the corals won't be able to recover. Most alarming is that this is the seventh mass bleaching event since the late 1990s. Scientists are increasingly asking how much the reef can take before recovery isn't possible.

Our journey to One Tree Island had begun the day before with a ferry ride that took us 80 kilometres offshore from Gladstone on the Australian mainland to Heron Island Research Station.

This region is far enough south that, before now, cooler waters and good luck have largely shielded it from mass bleaching, says Stuart Kininmonth at the University of Queensland. The reefs here are also some of the most highly protected and well managed in the marine park, he says. At One Tree Island, for example, public access and fishing is illegal and all activities other than research are prohibited.

34.4°C

Water temperature at Heron Island on 6 February (93.9°F)

The fact that reefs so far offshore, distant from pollution, exploitation and development, are bleaching is extremely significant, says Kininmonth.

Heinrich Breuer picked up Ward and me in his boat from the jetty on Heron Island to cross the 20 kilometres towards One Tree Island. Breuer manages the One Tree Island Research Station, part of the University of Sydney, with his partner Ruby Holmes.

After about an hour, Breuer slowed the boat and we could see fields of coral on the sea floor rising up out of the depths as the ocean shallowed. For about 100 metres, as we passed over the coral wall, the reef was just a few metres below us and, in the crystal-clear waters, I could see a mosaic of bright colour.

Contrary to what many people believe, however, the Great Barrier Reef often under-delivers on colour when it is healthy. It is naturally dominated by browns and greens, which are the pigments

JAMES WOODFORD

PhD student Bella Marrable surveys bleached reefs

New Scientist video
Watch video of the bleaching James Woodford saw at One Tree Island at youtube.com/newscientist

of the photosynthesising algae that live inside the corals. What I saw looked so bizarre and dissonant, like a jigsaw puzzle interspersed with the wrong-coloured pieces.

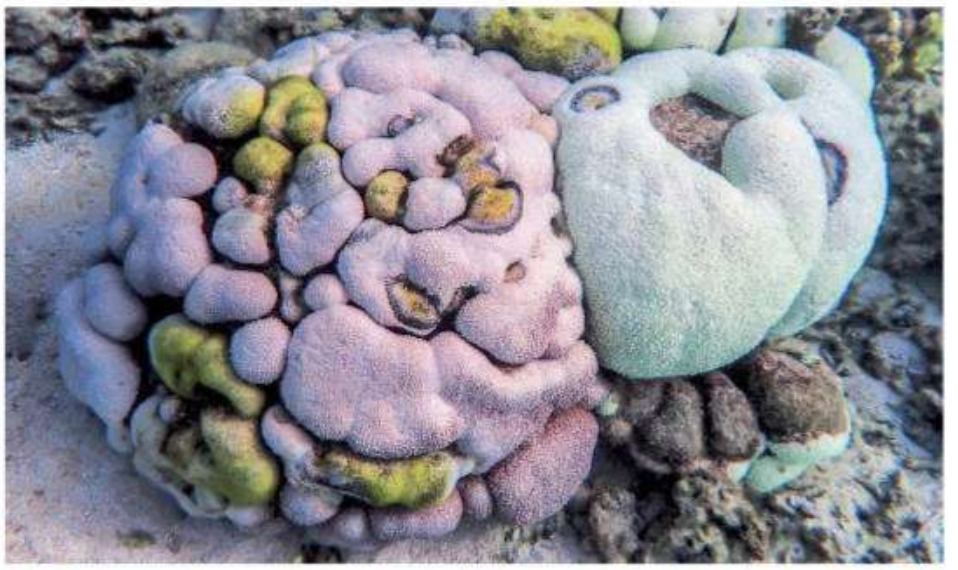
During a mass coral bleaching event, not all corals turn bright white. Counterintuitively, sometimes a bleached reef, like the one beneath me, can be exquisitely colourful. This is because when some corals are stressed, the healthy brown colours of the symbiotic algae are replaced by an explosion of psychedelic hues as the coral colonies increase the release of fluorescing pigments in response to warm water.

This is a defence mechanism for the corals: the pigments act like sunscreen to shield the remaining symbiotic algae, called zooxanthellae, which are vulnerable to bright light. "Having that pigment is a layer of protection for those remaining zooxanthellae, so it just gives them an extra chance at surviving," says Ward.

Soon, Breuer had pulled the boat alongside the shore at the station. To go diving outside the reef, we had to transfer immediately to a smaller boat as there were only another couple of hours before the tide would be too low to cross the reef again.

"It's pretty bad here. We're having trouble finding any spots where there is not a lot of bleaching"

Within a few minutes, we were back on the open ocean, getting ready to roll backwards into the sea. Ward went in first and I followed. As soon as the bubbles cleared from my mask, the scale of this bleaching event was even clearer – everywhere we looked was dead, bleached or fluorescing coral.



JAMES WOODFORD (ALL)

Bleached corals may appear white or produce fluorescent pigments (top) as a defence mechanism

We dived at another five sites and everywhere was the same. Even sea anemones, some of which have symbiotic algae in their bodies like coral, were bleached, though anemone fish were still swimming among their snow-white tentacles.

Exhausted and dismayed by the scale of coral stress we had observed, and with the tide falling fast, we returned to the research station. There we met Will Figueira, a researcher from the University of Sydney, who had rushed to One Tree Island once the scale of the bleaching had become apparent to set up a monitoring programme to assess how the fish and corals responded.

"It's pretty bad down here," says Figueira. "We're having trouble finding any spots where there is not a lot of bleaching. There's a few taxa and species that seem OK, but in the vast majority of locations they're either stressed or bleached, or in some cases there's already mortality happening."

Fluorescing bommies

Just after dawn the next morning, Ward and I snorkelled at one of the most famous sites at One Tree Island, called the Gutter. As its name implies, it is a shallow channel that, at high tide, leads to the open ocean.

We caught a ride on the incoming tide and drifted along for a few hundred metres. There were reef sharks, bull rays, shovel nosed rays and turtles, as well as vast schools of mullet. But by far the most striking sight was the fluorescing, boulder-like coral outcrops, or bommies, which were so colourful they looked like giant hard-boiled sweets. Every shade imaginable was on display and it was clear that something extraordinary and frightening is unfolding.

Later that day, we headed back to Heron Island with Figueira and his students, breaking the journey by diving at another five sites. Even in deeper water and at sites where the current was so strong we couldn't swim against it, there was no respite from the bleaching and fluorescing. Figueira used an underwater scooter to cover greater distances, but couldn't find any unscathed areas.

Emerging from one dive, he looked shocked at the scale of the bleaching in an environment that has the highest levels of marine park protection. Once the warming threat gets high enough, there are no management and conservation tools that can save the coral – global warming will just overwhelm it, he says.

Back on Heron Island, there was one more place that Kininmonth wanted me to see. Blue Pools is one of the island's most famous dive sites and parts of it were 100 per cent bleached. "All colonies were bleached to some extent and some have died," says Kininmonth.

"To see a whole reef going from being pretty healthy, robust, greens and browns, and then to see it go into this bright white and blue, fluorescent image is amazing," he says. "A month and a half ago that was a comfortably healthy site."

Kininmonth says the critical thing for the reef now is time. The corals need time to recover and recolonise the reefs. "Another hot summer would be a disaster," he says. ▮

Neuroscience

Newborn babies recognise nursery rhymes they heard in the uterus

Moheb Costandi

BABIES aged just 2 weeks old seem to recognise nursery rhymes that were spoken to them in the uterus. The extent to which they can do this then predicts their language development, which could identify individuals at risk of language-related conditions.

In 2013, a study suggested that newborns and 4-month-old babies could recognise the lullaby *Twinkle, Twinkle, Little Star* after it was played to them in the uterus. But it was unclear if the infants were remembering the melody, the lyrics, the rhythm or all three.

To get a clearer picture, Cristina Florea at the University of Salzburg in Austria and her colleagues recruited 60 pregnant women and randomly assigned them to two groups. Each group was asked to play recordings of one of two German nursery rhymes to their abdomen twice a day from the 34th week of pregnancy onwards. Both the nursery rhymes were spoken.

The researchers also created altered versions of the nursery rhymes by changing their rhythm, reversing them and removing high-frequency sounds.

Two weeks after the women gave birth, the researchers played both nursery rhymes to the babies while measuring the electrical activity in their brains. This indicated whether they were familiar with the rhymes and how easily they paid attention to them.

The team found that the nursery rhyme the babies had heard before seemed easiest for them to follow. In contrast, the unfamiliar rhyme elicited a stronger electrical activity response, suggesting that the infants exerted more cognitive effort when listening to it.

Language learning is thought to begin before a baby is born

SALLY ANSCOMBE/GETTY IMAGES

The researchers also played the altered nursery rhymes, finding that they were harder for the babies to follow than the unmodified ones, further suggesting that they could discriminate between the recordings and that the infants recognise more than just the melodies of the nursery rhymes.

Overall, the study shows that "babies can tell familiar rhymes apart, emphasising how important the rhythm and tone of speech are for them to learn language early on", says Nayeli Gonzalez-Gomez at Oxford Brookes University in the UK.

The researchers followed up on the infants when they were 6 months old, finding that the extent to which their language abilities had developed correlated with how well they tracked the nursery rhymes at 2 weeks old (bioRxiv, doi.org/mqcg).

Neural speech tracking after birth could therefore offer a way to gauge the risk of developing language-related conditions.

"It's very hard to reliably evaluate the language development of a preverbal child, and with a newborn, it is practically impossible, [however] neural tracking methods could evaluate children from birth, make a prognosis or help in recommending therapies," says Florea. ▮

Life

Rock networks may have boosted vital chemistry for life

CHEMICAL reactions key to the origin of life on Earth could have occurred within a natural laboratory of hot, thin rock fractures deep underground, in which many of life's building blocks were concentrated and separated from other organic molecules.

Christof Mast at the Ludwig Maximilian University of Munich in Germany and his colleagues created a heat flow chamber about the size of a playing card to model how a mix of organic molecules might behave in such rock fractures. They heated one side of the chamber to 25°C (77°F) and the other to 40°C (104°F), creating a temperature gradient along which molecules would move. How sensitive a molecule is to this process depends on its size, electrical charge and how it interacts with the fluid in which it is dissolved.

In an 18-hour experiment, the researchers found a variety of molecules were concentrated at different parts of the chamber according to their sensitivity. Among these molecules were many amino acids and the A, T, G and C nucleobases, which are key components of DNA. When the researchers created a network of three linked chambers, again with a temperature gradient, the extra chambers further enriched the compounds.

In a mathematical simulation with 20 interconnected chambers, they found the enrichment of

3000x

Difference in concentration between two amino acids

different molecules could be amplified yet again. In one chamber, the amino acid glycine reached a concentration around 3000 times higher than that of a different amino acid, isoleucine, despite starting at the same concentration (*Nature*, doi.org/mqcf).

Evan Spruijt at Radboud University in the Netherlands says the work is interesting, but points out that enrichment in rock fractures is still far from a viable scenario for an origin of life. "They still need to come together to form anything that resembles a cell." ▮

James Dinneen

Environment

Green tech mining threatens great apes

GREAT apes living in Africa are under threat from demand for minerals that are critical to the creation of green energy tech, such as electric vehicles.

Africa houses four great ape species: chimpanzees, bonobos and two species of gorilla. Many live in regions seen as potential mining sites for commodities such as cobalt and graphite.

To assess the scale of the threat, Jessica Junker at the non-profit conservation group Re:wild in Austin, Texas, and her colleagues compared operational and planned mining sites across 17 African countries with data on ape populations. In total, 180,000 great apes – just over one-third of the entire continental population – could be at risk (*Science Advances*, doi.org/mqcn).

Madeleine Cuff

80S_GIRL/GETTY IMAGES

Mind

How we feel the music inside us

WHEN music takes a different turn from what we are expecting, it seems to trigger a strong sensation around the heart, whereas those that follow an easy-to-anticipate pattern feel like they hit us in the gut.

Tatsuya Daikoku at the University of Tokyo in Japan and his colleagues asked 527 volunteers to listen to eight patterns of musical chords and report where on their body they felt a physical reaction.

The team found that when the first three chords followed an easily predictable pattern, the fourth triggered different physical responses. If that next chord continued with the expected musical pattern, people felt it in their abdomen, but if it deviated, they felt it around their heart (*iScience*, doi.org/mqgj).

Christa Lesté-Lasserre

Life

Snakes show signs of self-recognition with sniff test

SOME snakes seem to respond differently to their own scent when it has been altered, which hints that they have a form of self-recognition.

A handful of animals, including roosters, horses and cleaner fish, have shown signs of self-awareness in what is known as the mirror test. This involves putting paint on an area of their body that they can't see without a mirror, such as their forehead. If the animal touches the mark when looking in the mirror, it suggests that they are aware that the reflection is of themselves.

"But snakes and most reptiles primarily interact with their world through scent," says Noam Miller at Wilfrid Laurier University in Canada. So he and his colleagues challenged them to an alternative, smell-based version of the mirror test.

The researchers collected the scents of 36 eastern garter snakes (*Thamnophis sirtalis sirtalis*, one pictured) and 18 ball pythons (*Python regius*) by wiping cotton pads along their skin.

Each snake was presented with various scents, including a modified version of their own. The garter snakes performed more long tongue flicks in response to the modified scent compared with the others (*Proceedings of the Royal Society B: Biological Sciences*, doi.org/mqch).

"They only do long tongue flicks when they're interested in or investigating something," says Miller. "They may be thinking: 'Oh, this is weird, I shouldn't smell like this.'"

Ball pythons, on the other hand, responded in the same way to all the scents. Garter snakes are more social than ball pythons, says Miller, so it may be that social species are more likely to have self-recognition. **Chen Ly**

Really brief

YALONDA M. JAMES/SF CHRONICLE VIA GETTY IMAGES

San Francisco EVs clearly cut carbon

The growing popularity of electric vehicles has helped drive an almost 2 per cent annual decrease in carbon emissions for the San Francisco Bay Area between 2018 and 2022 (*Environmental Science & Technology*, doi.org/mqhs).

Heat makes it hard for trees to tell time

The circadian clock of *Nothofagus pumilio*, a southern beech tree common in Patagonia, is severely compromised when the trees are planted at temperatures warmer than their typical niche. This suggests that global warming can disrupt trees' ability to track time, with potential consequences for their capacity to sequester carbon (bioRxiv, doi.org/mqb6).

Marine protection is no help for fish

Fish populations aren't bouncing back in marine protected areas in the Caribbean Sea, according to a 12-year study. Poor enforcement of marine protection regulations, coastal development and rising water temperatures are probably to blame, say researchers (*Global Change Biology*, doi.org/mqhv).

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Views

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Tackle inequality to save the planet, says **Graham Lawton** p22

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Emily H. Wilson on Adrian Tchaikovsky's latest novels p30

Comment

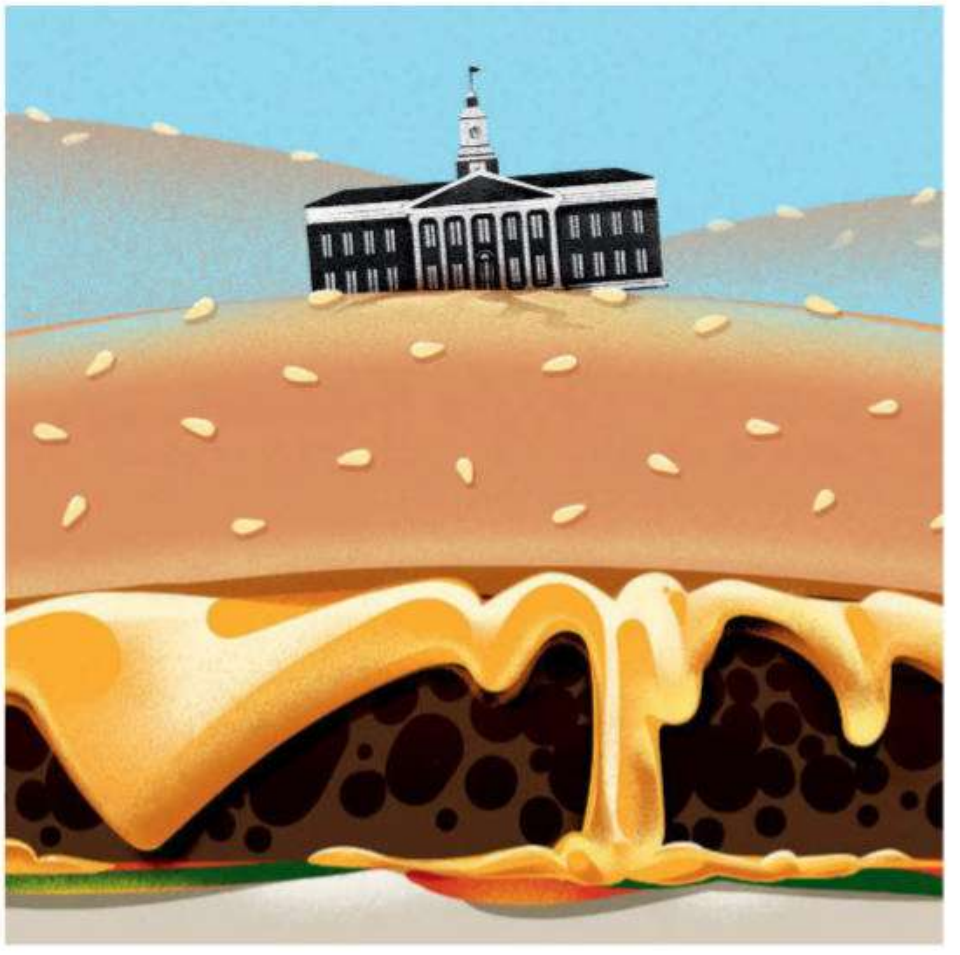
We are what we eat

Nutrition must be as essential as maths or science at US educational institutions to solve the country's obesity crisis, says **Aman Majmudar**

MARCH was National Nutrition Month in the US, the latest in a decades-long campaign to improve eating habits. This year's theme was "Beyond the Table", highlighting how food gets from farms to markets to our plates, how we might store and treat food safely at home and how we can reduce food waste.

Though these are important topics, such education must happen more often if it is to help curb a worsening chronic illness crisis. Nearly half of US adults will be obese in 2030. Obesity increases the risk of over 200 other conditions, from arthritis to breast cancer. Yet a 2020 study noted that half of young people in the US have poor-quality diets; so do many college-educated adults. More recent research found that most people in the US overestimate their diet's quality. As a student, I have noticed that long-term solutions to this crisis seem like an afterthought, with schools and universities neglecting to educate young people about nutrition.

We college students know so well what to expect from our first year in the dining halls that the phenomenon has a name, the "freshman 15", poking fun at how students gain around 15 pounds in their first year of study, more than is seen in the general population. At my college, the University of Chicago, I have certainly seen some of my peers load their plates with only burgers, fries and pizza, wolfing them down in their rush to attend afternoon classes. But it isn't necessarily their intention to eat unhealthily.



ADRIA VOLTA

My college is like many others. It doesn't spend resources to offer nutrition as a major or have a department focusing on the topic. Nor do we get comprehensive healthy eating guidance at the dining hall – it simply claims it offers healthy food, with pictures of fruit and vegetables on posters, and informs us about ingredients. We do have dieticians, but few of my peers know they exist, let alone consult them. At the resident halls where we learn about maintaining our health and well-being at college, I have noticed little nutrition education beyond a PowerPoint slide during orientation of new students. Perhaps universities don't want to bore us with something they believe we have already learned.

But that is far from the case. Our parents' dietary habits influence, if not determine, our own, and we know that many young people are stuck with how little their parents know about nutrition. The current education system tries to solve the problem, though only on paper. US schools for children up to the age of 18 participate in the National School Lunch Program, which means they are legally required to have nutrition education policies, such as limiting social events that serve unhealthy foods, surveying students and parents to determine appealing and healthy choices and involving parents in nutrition workshops. Yet several studies have noted the policies' inconsistent execution.

Colleges could help by using their status as research institutions to keep students up to date on the nutrition field. They could show us how scientists think about nutrition – asking us to evaluate our diets based on what our own bodies need, for example, something one course at my college teaches, though it isn't mandatory. Such courses could teach us how to think, rather than what to think, about nutrition. They could also offer experiential classes like cooking and gardening. Ideally, we could then take these lessons home to our parents.

The biggest challenge here is the prevailing attitude towards nutrition. Changing this requires long-term commitment, because the effects of healthier eating among the public take decades to manifest. Education can help fix this attitude. But if our schools and research institutions continue disregarding nutrition, so will all those who follow their example.

Aman Majmudar is at the University of Chicago, Illinois. His BA thesis is about reforming US food additive regulation

No planet B

A rich man's world

Inequality is a major obstacle to sustainability. We can't get to net zero without tackling it – and talking about redistribution, says **Graham Lawton**

Graham Lawton is a staff writer at *New Scientist* and author of *Mustn't Grumble: The surprising science of everyday ailments*. You can follow him @grahamlawton

Graham's week

What I'm reading
Limitarianism: The case against extreme wealth *by Ingrid Robeyns*

What I'm watching
3 Body Problem *on Netflix*

What I'm working on
Paying off my new boiler

This column appears monthly. Up next week: Annalee Newitz

I RECENTLY had to replace the hot water system in my house. It cost a small fortune. I'm fortunate enough to be able to afford it, but I couldn't go to the next level, a heat pump. My carbon footprint will be lowered by my new boiler, but it won't be where I want it to be: zero.

If I can't afford it, god only knows how the majority of people ever will. But there are those living not far from me who could buy a heat pump for every house in London and hardly feel the pinch. They are the super-rich, and they are an environmental horror story, for two reasons.

The obvious one is excessive consumption. According to the United Nations Environment Programme, the average greenhouse gas emissions of someone in the richest 10 per cent of global society (yes, including me) are around 20 times the average of someone in the poorest 50 per cent. Research by Oxfam and the Stockholm Environment Institute found the world's richest 1 per cent collectively emit the same as the poorest two-thirds.

A new book by Ingrid Robeyns puts this in stark personal terms. In *Limitarianism: The case against extreme wealth*, she calculates that to get to net zero, the average per capita carbon footprint needs to be 2 tonnes a year. The European average is 8 tonnes. The top 1 per cent emit over 100 tonnes, with billionaires emitting a mind-blowing 8000 tonnes, mostly through the use of private jets and superyachts.

There are very few billionaires, but their consumption is only part of the equation. Huge inequality is bad for everyone – and the planet.

That much was made plain by the 2009 book *The Spirit Level* by social epidemiologists Kate Pickett and Richard Wilkinson. In a recent webinar about the book, Pickett said: "What *The Spirit Level* showed was that economic inequality, specifically income inequality, was related to a whole range of different problems: health problems, issues to do with human capital development, such as educational attainment and social mobility, and everything to do with relationships. The crucial point is that inequality seems to affect almost all of society." In the years since 2009, the evidence for this has only grown stronger.

As for the environment, inequality isn't just bad for the obvious reasons. A recent paper

"Research has found that people living in highly unequal parts of the US tend to spend more on swanky cars"

in *Nature Climate Change* makes a compelling case that inequality is a major obstacle to sustainability, because people at the lower end of the income spectrum don't have the resources – money and time – to make the necessary lifestyle changes. To return to my recent dilemma, installing a heat pump involves major up-front costs, and is only available to homeowners.

Not only does inequality limit people's opportunities to make sustainable choices, it also drives unsustainable consumption at lower income levels.

Humans are hardwired for "social evaluative threat" – anxiety about how we are seen by others. This threat induces a type of stress called status anxiety. Subconsciously, we are all evaluating where we stand in the economic pecking order and trying to climb to the next rung, or at least not slide down. One of the easiest ways to alleviate status anxiety is conspicuous consumption.

In any society, the poorest people have the highest levels of status anxiety and the richest the least. But here's the rub: in more unequal societies, status anxiety is higher across the board. One study found that in the most equal societies, the poorest have a status anxiety score of 2.2 out of 5, as judged by their degree of agreement with questions such as "others look down on me because of my job situation or income". The richest score about 1.8. In the most unequal societies, the scores are 2.7 and 2.1. In other words, the richest people in very unequal societies have roughly the same level of status anxiety as the poorest in more equal ones.

How do people respond to status anxiety? In part by consuming high-status goods. Multiple research projects have found that people living in highly unequal parts of the US tend to spend more on swanky cars and designer clothes, which have a very large carbon footprint. "Status competition driving consumerism upward is a huge obstacle to moving towards sustainability," said Wilkinson in the webinar with Pickett.

Many Western societies are still tolerating, or even encouraging, eye-watering levels of inequality. People tend to balk at policies that explicitly talk about redistribution, according to Luke Hildyard, author of *Enough: Why it's time to abolish the super-rich*. But they also underestimate the obscene wealth held by a few people who emit more than just greenhouse gases. It is a tough argument to make, but it has to be made. As Wilkinson said: "We cannot solve the environmental crisis without solving the inequality crisis." ▮

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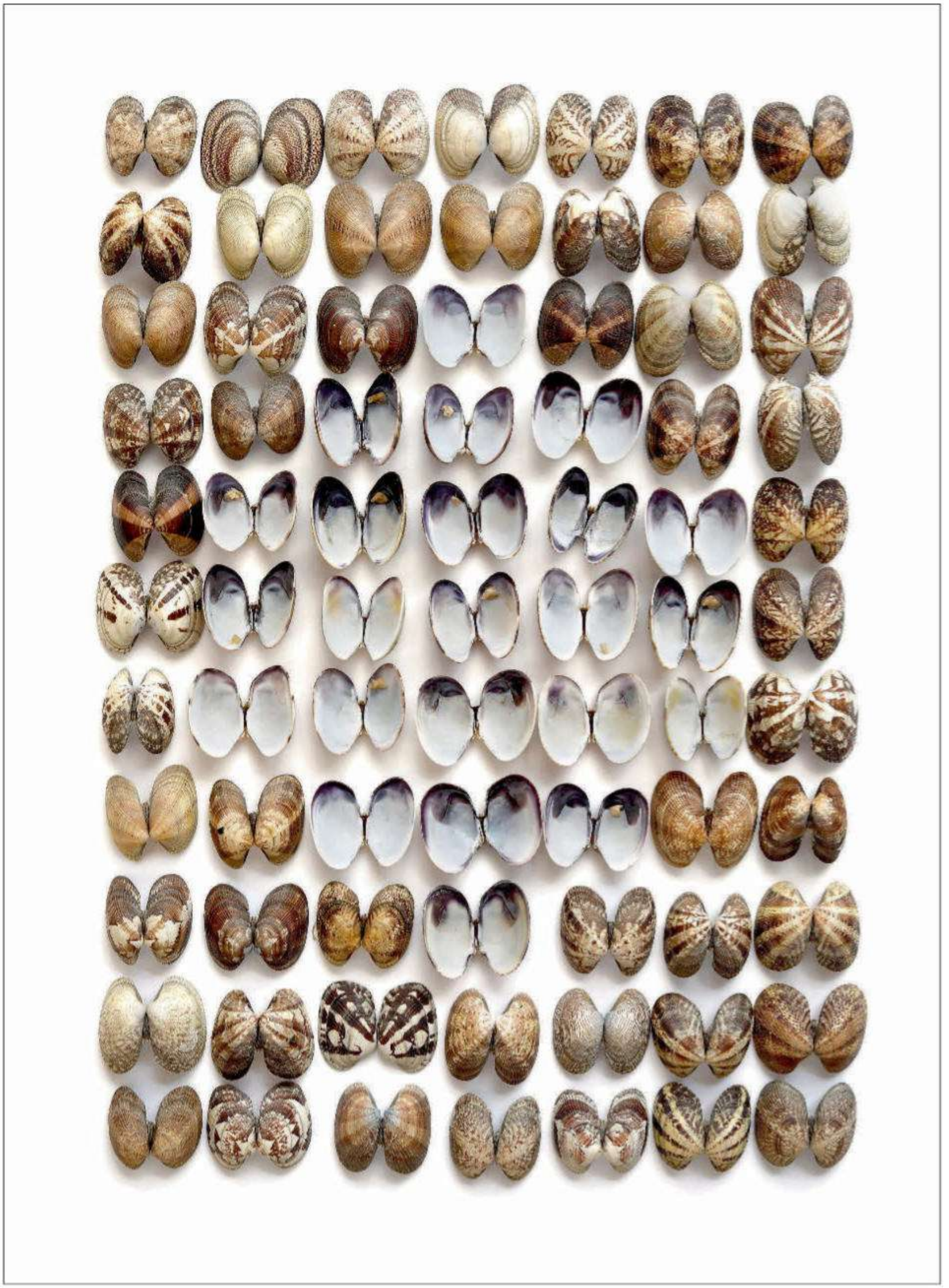

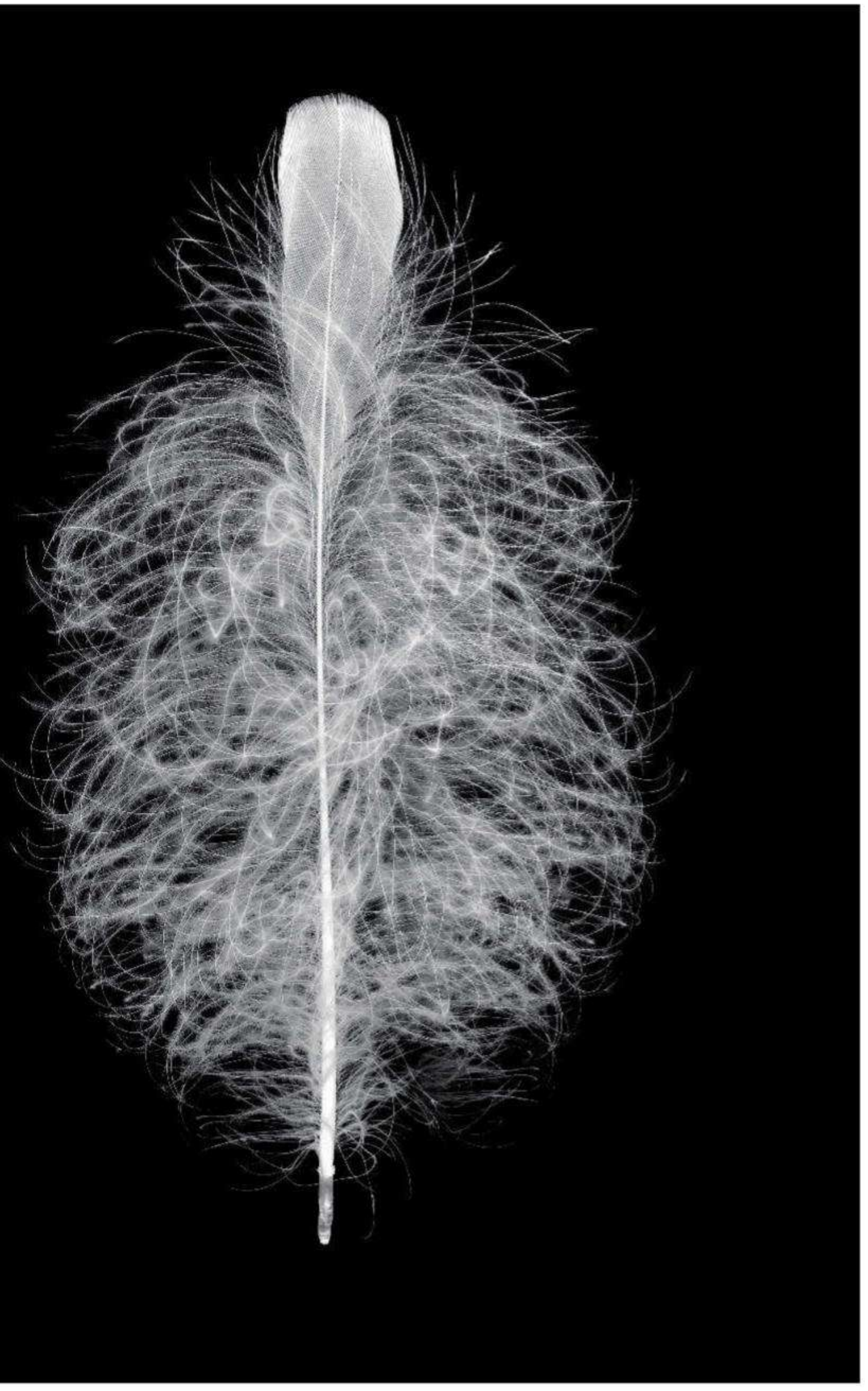

Daily beauty

Photographer **Mary Jo Hoffman**
Publisher **Phaidon**

THESE photos provide a snapshot into a decades-long creative endeavour celebrating the beauty of the natural world.

Since 2012, aeronautical engineer-turned-artist Mary Jo Hoffman has taken one photo a day of the natural objects around her. But what started out as a creative challenge to simply get better at art composition has now evolved into a "comprehensive way of being", she says.

Twelve years and thousands of photos later, Hoffman still finds beauty in her surroundings, often no further away than her home in Saint Paul, Minnesota. Her book, *Still: The art of noticing*, which will be published on 18 April, collects 275 photos from her project, two of which are shown here.

At far left are an assortment of palourde clam shells from the Mediterranean Sea, the remnants of a spaghetti and clam dinner in southern France. Hoffman wanted to commemorate the varied colouration of each clam, and this aftermath proved too good an opportunity to pass up.

At near left is a feather from a sandhill crane. Hoffman selected this downy number during the moulting season of a resident pair of cranes that have set up their summer nests next to her house.

Hoffman's background in aeronautics means her idea of beauty has always bent towards the mathematical – the intricacies of feathers, for example, seen with the naked eye or zoomed in to the finest details, illustrate "beauty at every level", she says.

As for the project, "I truly feel I have stumbled onto an elegantly simple practice that lets me experience the sacred almost every day," she says.

Gege Li

Editor's pick

Views on our weird and wonderful universe

23 March, p 32

From Wolf Kirchmeir, Blind River, Ontario, Canada

I like the clarity and brevity of Eric Schwitzgebel's summary of the reality problem: "What is the underlying structure of the universe and how does human consciousness fit into it?"

I think the underlying structure is something that won't be described by some synthesis of quantum physics and general relativity. Those two descriptions will turn out to be limited cases, somewhat like the way Newtonian physics is a limited case of general relativity. If, that is, humans are capable of constructing such a description. We may not be.

As for consciousness, I think it will turn out to be neither a property nor a constituent of the universe.

From Carl Zetie, Raleigh, North Carolina, US

Schwitzgebel may be overpessimistic in suggesting it is hard to justify a 99.999999 per cent level of confidence that we don't live in a simulation. We probably do live in a simulation, according to reasoning put forward most prominently by philosopher Nick Bostrom. That is because simulated universes will make their own simulations, and so on. Consequently, there will be a vast number of simulated universes and a single real one, so it is very unlikely to be ours.

From Adrian Bowyer, Foxham, Wiltshire, UK

"Positing Zorg the Destroyer, hidden at the galactic core and pulling on protons with invisible strings, would rightly be laughed away as an explanation for anything," writes Schwitzgebel.

But that is exactly the explanation for everything in our daily experience. We call "Zorg the Destroyer" the "Sagittarius A* black hole", and it pulls on protons (as well as other matter), with the invisible strings of gravity keeping them, and hence us, in orbit around the galactic core.

Yes, science can create the benefits of religion

2 March, p 44

From Ria Maenhaut, Ghent, Belgium

David Robson wonders whether the spirituality of science could provide the perks of religion. When, years ago, I read Richard Dawkins's *The Ancestor's Tale: A pilgrimage to the dawn of life*, I felt a deep unity with all living things. I thought it funny that the world's best-known atheist caused my spiritual experience.

Later, I watched the series *Life on Earth* (again) and when it showed a flatworm and a sea squirt, my heart was filled with reverence for these creatures. Science surely has given me the perks of religion!

Ed – For more on spiritual experiences inspired by science, see page 44

Could we do away with the fear of death itself?

23 March, p 36

From Rowan Mitchell, St Albans, Hertfordshire, UK

Venki Ramakrishnan's take on the most promising ways to stop ageing gave a realistic appraisal of the state of the science. But I was particularly struck by his discussion about the need to accept mortality and how hard it is to do this gracefully.

Any intervention that increases longevity substantially is likely to require altering our fundamental biology. But I feel a much better aim, for both the sum of human happiness and the planet, would be to make people lose their fear of death as they age, so they enjoy every day until their last.

The perils and promise of extreme geoengineering

16 March, p 36

From Angela Cotton, Southampton, UK

I read "Megaprojects that could save the world" with a sense of despair. Intentionally or not, any such efforts will just distract from decarbonising using the technologies that we already have.

The last thing we need is a huge outlay in emissions to make space-based solar power, concrete islands for wind power and vast direct air capture plants. Faced with the great cost of removing carbon dioxide, perhaps demand reduction in hard-to-decarbonise sectors, like aviation and shipping, will become more palatable – especially if those sectors are asked to pay for CO_2 extraction.

From Richard Hambly, Sydney, Australia

A space-based solar power station sounds doable with advances in rockets. As for where to put the many large rectennas required on Earth to collect the energy beamed down, Australia has a lot of land and not all of it is remote from coastal populations. We aren't short of ideas and technology is galloping along at a rate that may save us from ourselves.

From William Hughes-Games, Waipara, New Zealand

It seems unlikely that generating vast quantities of renewable energy to suck carbon dioxide from the air and deposit it somewhere would be more effective than simply using the same amount of renewable energy to displace the use of fossil fuels.

Making decisions with little chance of regret

16 March, p 32

From Ben Craven, Edinburgh, UK

David Robson writes about how to make big decisions that we won't regret. Coming to the belief that I don't have free will has brought the unexpected benefit of making me much less likely to regret past decisions, on the grounds that I didn't really have a choice at the time. Nevertheless, in the present, the experience of having free will is so compelling that it would be impossible not to play along with it. My mind seems happy to handle the contradiction of believing in an inevitable past while acting as if I had an open future.

From Pamela Ross, Findochty, Moray, UK

I have made several big life choices, including drastic changes in occupation, and regretted none of them. More recently, I uprooted myself from my home of 30 years and moved an 8-hour drive away to a part of the country I had only fleetingly passed through six years earlier, a place I wasn't familiar with and where I knew no one. Quite a drastic decision, but, again, one I haven't regretted.

Counting down to the next great rocket launch

23 March, p 7

From Paul Fink, Natalia, Texas, US

There is no reason for negativity over the latest launch of SpaceX's Starship. At lift-off, all 33 of the first-stage engines lit and stayed that way, as planned. The second stage then completed a successful "hot staging", firing up its six engines before it separated and entered orbit. Both stages were lost – as was meant to happen. That they were both lost a little earlier than hoped wasn't ideal, but also wasn't the point of this flight.

It is almost impossible to oversell the success of this third test, and there are four more first-stage rockets ready to go. ▮

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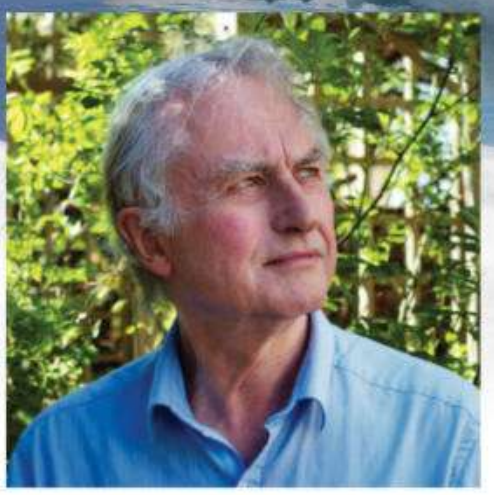

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A healthy balancing act

It is tough turning neuroimmunology into a gripping read, but this excellent book makes for a delightful and authoritative overview, says **Grace Wade**

Book
The Immune Mind
Monty Lyman
Torva

AT UNIVERSITY, I had two roommates with irritable bowel syndrome (IBS), a painful condition affecting the digestive system. Both also had anxiety. But there was a key difference between them that stuck with me. While one found IBS treatments attenuated her anxiety, the other found relief through the opposite approach: her stomach pain only eased after seeing a psychiatrist. It was an astonishing lesson for me in the complexity of the relationship between body and mind.

This intricate connection forms the foundation of *The Immune Mind: The new science of health* by Monty Lyman, a medical doctor and research fellow in psychiatry at the University of Oxford. Lyman explores the complex, fascinating connection between our bodies, our minds and our gut microbes. He argues that viewing physical and mental health as separate entities has been detrimental to our well-being. Instead, we need to see our bodies as a delicate balance between brain, immune system and gut. Only then can we become our healthiest selves.

Lyman's passion for the subject is evident from the start. Rather than shying away from the complexity of the immune system, he embraces it, carefully detailing how and why immune responses occur. Yet his writing is rich, playful and illuminating. He describes the immune system as a "gossipy community" that "blends the balance of a ballerina with the offensive capabilities of an elite Marine unit". Such metaphors transform dense subject matter into a breezy and delightful read.

The book starts by unravelling the long-standing belief that the brain and body are distinct, with Lyman citing some remarkable findings. For example, in a 1970s study, researchers gave immune-suppressing drugs to rats along with sugar water. After a few bouts, they started giving the sugar water without the drug. This was enough to greatly reduce the rats' immune responses. A few even died.

Research has increasingly shown that the brain and immune system generally work in tandem to anticipate threats. But this can go wrong, as Lyman points out, sometimes leading to a reaction when no real danger is present. Some schizophrenia cases are misdiagnosed and are actually instances of the immune system mistakenly attacking the brain, for example. One woman spent 20 years in a psychiatric hospital before her doctors discovered she had lupus, an autoimmune condition that could be treated using immune-suppressing drugs.

Real-life stories like this run through the book, helping to ground complicated biological processes in real experience. Lyman also cites a large number of recent findings, making the book a worthwhile read even for those who are familiar with the area. For example, Carolyn Bramante at the University of Minnesota and her colleagues found that people treated with the diabetes drug metformin, which has effects on the gut microbiome, were 41 per cent less likely to develop long covid than those who weren't.

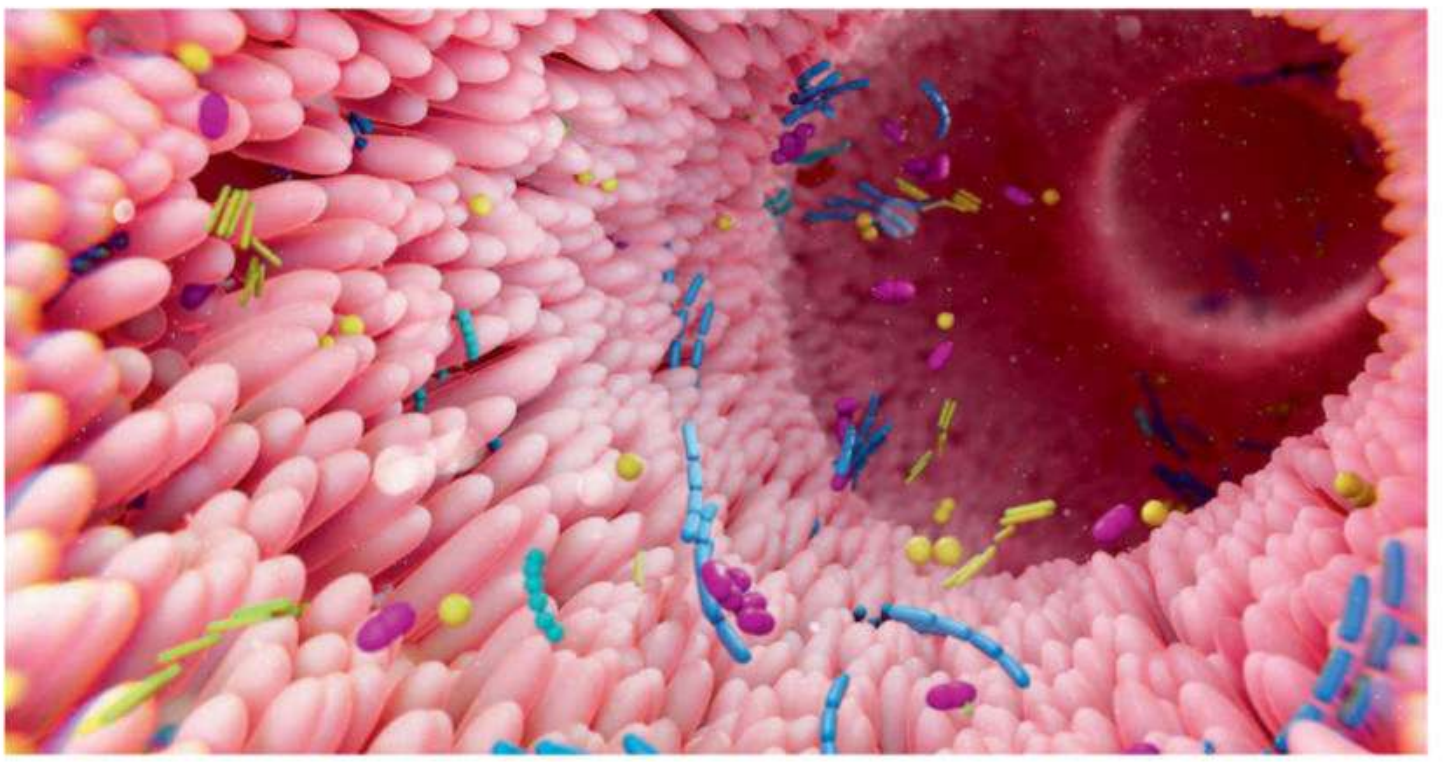
"Some schizophrenia cases are misdiagnosed instances of the immune system attacking the brain"

The Immune Mind wraps up by exploring how we can bolster our body's defence system. This is probably the least substantial bit – and I think Lyman would agree. Still, there is sound advice, such as eating a fibre-rich diet and regularly exercising as a means of strengthening immunity.

The trouble is that lifestyle fixes can't solve all our health problems. Nor does Lyman pretend they can. He emphasises the limitations of diet, movement and sleep. There is "no best chess-move – it depends on the context", he writes. It seems obvious, but this message is often lost in a world of general advice on lifestyle and wellness.

At times, the book's accessibility can feel forced. Most chapters open with an anecdote or example to illustrate their theme. This mostly works, but can misfire, such as when Lyman uses a few hundred words on border disputes between Egypt and Sudan as a segue into how some chronic conditions don't fit into a single specialty.

But this is nitpicking about a book I highly recommend for its comprehensive, eye-opening overview of the interplay between the immune system, mind and gut microbiome. As a health writer too, I tip my hat to Lyman: turning neuroimmunology into a page-turner is no easy feat. ▮



THOM LEACH/SCIENCE PHOTO LIBRARY

What goes on in the gut microbiome (illustrated) may affect brain health

Apocalypse, forever

From the Book of Revelation to extinction fiction, we can't get enough of end times. **Bethan Ackerley** enjoys a rich guide

Book

Everything Must Go
Dorian Lynskey
Picador, UK
Pantheon, US, November 2024

COLIN TEMPLE/ALAMY

TO THE surprise of almost no one, the big winner at the Academy Awards last month was *Oppenheimer*, Christopher Nolan's biopic of the father of the atomic bomb. The film's success speaks to our age-old obsession with end times. Be it fire, flood or pestilence, humanity has always fantasised about its doom.

In *Everything Must Go: The stories we tell about the end of the world*, writer Dorian Lynskey explores this curious impulse and how it has shaped modern culture. He starts by addressing that most influential and fervid of religious cataclysms, the Christian apocalypse outlined in the Bible's Book of Revelation. This was later overtaken by fears of the atomic bomb, he argues, yet Revelation imagery still pervades modern eschatology, the branch of theology studying the end of days.

In pinpointing the first narratives about a secular apocalypse, Lynskey adds forgotten details to a well-worn moment of literary history: that gloomy summer of 1816 when Mary Wollstonecraft Godwin and Percy Bysshe Shelley joined Lord Byron and John William Polidori in Geneva, Switzerland. A writing contest between them resulted in *Frankenstein*, by Wollstonecraft Godwin (published under the name Mary Shelley – she had married the poet by then). It also produced *Darkness*, a poem by Byron that Lynskey calls "a radically godless vision of the end of the world".

Less well known is the crisis in which it occurred. The previous year, Mount Tambora in the Dutch East Indies (now Indonesia) had erupted, spewing out so much dust that global temperatures dropped by 0.7°C, turning 1816 into "the year without a summer". Famine and typhus swept Europe. So, too, did proselytising that the end was nigh.

In its 500-odd pages, *Everything Must Go* documents the threats faced by civilisation over the years, some more real than others. Each chapter, focusing on scenarios such as the rise of machines or a catastrophic fall in fertility, offers an uneven mix of culture and science. Some chapters favour the former, including one on what Lynskey calls "impact fiction", concerning asteroids, comets and planets striking Earth. Others, like a section on the development of nuclear weapons, firmly focus on science.

Lynskey makes pleasing connections between disparate sources of potential catastrophe. "The first person ever to sketch the contours of a mushroom cloud was the young physicist Luis Alvarez, who watched the Trinity test from the cockpit of an observation aeroplane," Lynskey writes. Alvarez and his son Walter would later show that an iridium-rich sediment layer found worldwide indicates that an asteroid impact triggered the mass extinction of the dinosaurs.

Our fascination with end times might be partly down to one of our many cognitive biases

While it is a comprehensive guide to how humanity has imagined its doom, *Everything Must Go* is less convincing when it comes to what that means. You may wonder why we are obsessed with end times, for instance. Lynskey does float a few ideas. Chronocentrism – the cognitive bias that we live in an unprecedented moment capable of definitively shaping the future – could play some part, as could the prevailing belief that, in some way, we deserve destruction for our sins, religious or otherwise.

There are insights into the minds of those particularly drawn to apocalyptic narratives. For example, some experts think that doomsday prepping is unique to the US, part of the rugged individualism shaping that nation. But readers may crave a more scientific basis for Lynskey's statements on human nature.

That said, his book is filled with lesser-known cultural gems. And by saving some of his most interesting arguments for the final section on climate and the epilogue, Lynskey has succeeded at a difficult task: how to end a book about endings.

New Scientist *recommends*

Jacob Aron
News editor
London

Before I read **When the Dust Settles** by Lucy Easthope, I hadn't even realised disaster recovery was a discipline – the aftermath of a tragedy seems too raw to be an object of study. I stand

corrected, thanks to her compassionate book.

Over the past 20 years, Easthope, a professor of risk and hazard at Durham University, UK, has been involved with UK disasters (or ones involving its citizens): from terrorism to the Fukushima meltdown and the covid-19 pandemic (the UK's covid memorial wall is shown above). She details mistakes and triumphs, and how we can do better. Essential reading.

I am also enjoying **The Family Experiment** (out in May) by John Marrs, who has perfected a light sci-fi genre – think *Black Mirror* meets *EastEnders*. His books are set in a near-future UK, where DNA swabs reveal our perfect partners and driverless cars can be hijacked. This latest sees couples who can't afford children raising virtual ones in a reality TV show. Slightly ludicrous, but fun.

GUY BELL/ALAMY

The sci-fi column

Double helpings The prolific Adrian Tchaikovsky has two terrific offerings out this year. One is the story of a scientist turned prisoner shipped to a faraway planet, the other is a light-hearted tale of robotic murder, says **Emily H. Wilson**

Emily H. Wilson is a former editor of *New Scientist*. *Gilgamesh*, the second novel in her *Sumerians* trilogy, is out later this year. You can find her at emilyhwilson.com, or follow her on X at @emilyhwilson and on Instagram at @emilyhwilson1

GREMLIN/GETTY IMAGES

In Adrian Tchaikovsky's *Alien Clay*, prisoners live on a hostile alien world

BRITISH writer Adrian Tchaikovsky has not one, but two new novels out in the first half of this year. That may be due to the vagaries of publishing, rather than evidence of exceptional productivity. However, Tchaikovsky is certainly prolific: his backlist is as long as your arm. He is also a huge talent, writing at the peak of his powers.

The first of these two new novels, published last month, is *Alien Clay*. Sometimes, I question whether a book really counts as science fiction or not, but this is a story of alien life on a faraway planet and the colony of humans plonked down on it – it is hard to think how it could be more sci-fi.

The novel underlines one of Tchaikovsky's many strengths. Other writers rely on flashy physics. Tchaikovsky is brilliant at sci-fi rooted in biology, as his Hugo award-winning *Children of Time* series exemplified. That explored the endpoint of spiders (and later octopuses) achieving cognitive "uplift", and the science of it was sensationally well handled.

In *Alien Clay*, the local flora/fauna (it is hard to say which really) is an infectious, confusing mess. The planet is also studded with long-abandoned buildings, adding mysterious archaeology to the mix.

Our scientist hero has fallen foul of Earth's repressive ruling regime and been shipped out to this world as a prisoner. He will have to quickly learn the ropes of the colony and the planet itself... or he won't be alive for long.

"Uncharles is optimistic about his career prospects, despite his murder tally being 'non zero', as he puts it"

It is possible that, with less politics and backstory, this book could have been a stone-cold classic rather than just an excellent stand-alone novel, but that is nit-picking. The last third of *Alien Clay*, especially, is heart-in-the-mouth fantastic.

Tchaikovsky's second offering of 2024 (so far) is *Service Model*, out in June. This is a tonally lighter book, despite its dystopian setting.

It is the story of a robot named Uncharles. He was originally Charles and worked as a gentleman's valet, but after an unfortunate incident with a razor, he finds himself jobless, renamed and on the road.

Uncharles is a wonderful companion, as is his unusual robot friend, The Wonk, who he meets along the way. We spend the whole book in Uncharles's head as he carefully follows his programming decision trees to make sense of what to do next.

He is buoyantly optimistic about his career prospects, despite his murder tally unfortunately being "non zero", as he puts it. Uncharles hopes that if he can keep his murder rate low enough, his indiscretions will be forgiven. After all, think how good he is at organising travel itineraries! Finding a new job as a high-end valet proves extremely difficult, though, in a world going to hell in a handcart.

Service Model would make a delightful and very funny buddy movie. You find yourself rooting strongly for Uncharles and wanting him to be sentient. But is he? Then again, is The Wonk (a very different creature) really free to make its own decisions?

I think it is fair to say that these novels are minor works when set against *Children of Time*. (My *New Scientist* colleague Michael Marshall recently described that as "one of the best series in modern science fiction and fantasy", and I heartily agree.) But even so, they are both vibrant novels bursting with life (be it artificial or alien) and I am glad to recommend them to you. ▮

Books

Alien Clay
Adrian Tchaikovsky
Tor

Service Model
Adrian Tchaikovsky
Tor, out 6 June

Emily also recommends...

Book

Salt
Adam Roberts
Gollancz
The politics in Alien Clay *and the remoteness of the planet at the heart of it reminded me of* Salt, *first published in 2000. They are very different novels, but both use the prism of colonists settling on an alien world to explore what it means to be human.*

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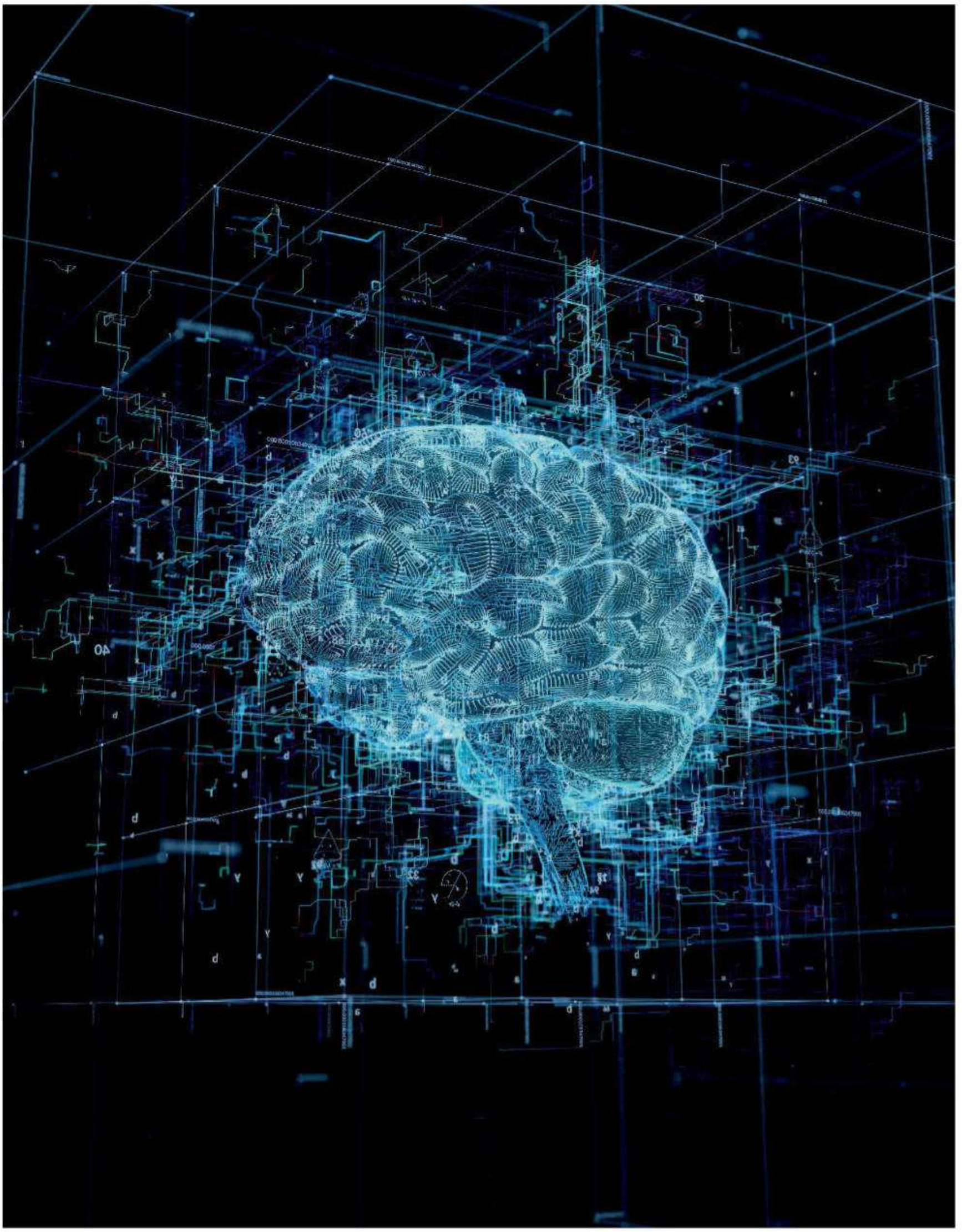

SIMON DANAHER

Proof of intelligence?

AIs that tackle maths' hardest problems may herald human-level reasoning. Can they pave the way to artificial general intelligence, asks **Alex Wilkins**

IN PURE mathematics, very occasionally, breakthroughs arrive like bolts from the blue – the result of such inspired feats of reasoning and creativity that they seem to push the very bounds of intelligence. In 2016, for instance, mathematician Timothy Gowers marvelled at a solution to the cap set problem, which has to do with finding the largest pattern of points in space where no three points form a straight line. The proof "has a magic quality that leaves one wondering how on Earth anybody thought of it", he wrote.

You might think that such feats are unique to humans. But you might be wrong. Because last year, artificial intelligence company Google DeepMind announced that its AI had discovered a better solution to the cap set problem than any human had. And that was just the latest demonstration of AI's growing mathematical prowess. Having long struggled with this kind of sophisticated reasoning, today's AIs are proving themselves remarkably capable – solving complex geometry problems, assisting with proofs and generating fresh avenues of attack for long-standing problems.

All of which has prompted mathematicians to ask if their field is entering a new era. But it has also emboldened some computer scientists to suggest we are pushing the bounds of machine intelligence, edging ever closer to AI capable of genuinely human-like reasoning – and maybe even artificial general intelligence, AI that can perform as well as or better than humans on a wide range of tasks. "Mathematics is the language of reasoning," says Alex Davies at DeepMind. "If models can learn to speak it fluently, we will have created a very worthy intellectual partner."

To understand the significance of AI taking on complex maths, you need to understand what human mathematicians do. Pure maths, as opposed to applied maths, is done with no practical purposes in mind. "Fundamentally, mathematicians are trying to understand," says Jordan Ellenberg at the University of Wisconsin–Madison. They aim to find fundamental relationships and principles by studying abstract objects and concepts, such as numbers, algebra and geometry.

In practical terms, this involves a series of steps. You first define your terms. Then you combine these definitions into a mathematical statement, or a conjecture, that captures how these definitions relate to each other. And finally, you convert your conjecture to a theorem by writing a proof, demonstrating not only that the statement is logically true and valid for many scenarios, but also, hopefully, showing why it is true.

Pure maths, then, requires sophisticated reasoning, intuition and creativity. "Reasoning is quintessential to the mathematical process," says Geordie Williamson at the University of Sydney in Australia. "In fact, it is difficult to find a discipline of human thought that exemplifies reasoning more." That explains why mathematical reasoning has long been prized as something special, something beyond the reach of even the most powerful computers. "A machine can take hold of the bare fact, but the soul of the fact will always escape it," wrote mathematician Henri Poincaré in 1908.

Mathematicians have used computers for decades, of course, but only for brute force calculations. When it comes to AI, even the wildly successful deep-learning neural networks – systems modelled on the way brains work – that have driven recent advances in the field have been unable to muster much in the way of mathematical reasoning. These days, however, there are signs that the latest AIs might be changing that.

Pattern spotters

Consider the Birch and Swinnerton-Dyer conjecture, a big open question in number theory. It concerns elliptic curves, defined by a certain kind of cubic equation in two variables, and in particular finding when these curves contain whole numbers. This conjecture is one of the seven Millennium Prize Problems selected at the turn of the century by the Clay Mathematics Institute in the US. Each is considered so challenging that anyone who can come up with a proof would bag a $1 million prize.

In 2019, some 70 years after this conjecture was put forward, Yang-Hui He at the London Institute for Mathematical Sciences and his colleagues wanted to see if AI could produce fresh insights. They directed a neural network to pore over a database containing millions of elliptic curves in search of a relationship between two mysterious properties – their rank, which is a characteristic of the curve, and a series of numbers called an L-function, which describe these curves in an alternate way.

The AI didn't disappoint, finding that numbers in the L-function could be used to precisely predict the rank. After analysing the AI's predictions in more detail, He and his colleagues found a striking statistical pattern that, when plotted on a graph, looked a lot like the fluid shapes produced by flocking starlings, known as murmurations. This work attracted more researchers, who have since found an equation to describe the pattern and found that it shows up in other important mathematical functions. "The AI was able to tell us to try something we ›

wouldn't have tried if we just used our own intuition," says He.

It was a similar story a year later, when a collaboration between mathematicians and DeepMind used a machine-learning algorithm to rifle through large databases of objects from two more branches of maths: knot theory and representation theory. Again, the algorithm found potentially interesting relationships between certain aspects in the databases and researchers did further analysis to find genuinely new conjectures.

"Mathematicians were tremendously sceptical about whether machine learning would have anything useful to say about actual mathematics," says Davies. Clearly, though, when it comes to spotting patterns in complex datasets, AI can perform tasks that human mathematicians can't, even if its workings are sometimes a bit opaque. Working with these systems is like having a collaborator who can't communicate well, says Williamson, who led the representation theory part of the project. "I always had the sense when working with these things that it somehow knows the answer, but it can't tell me why."

But there are reasons to think AIs can be more than taciturn pattern spotters. In 2022, OpenAI launched ChatGPT, a chatbot based on a form of AI known as a large language model (LLM). These offer fluent, human-like responses to all manner of prompts, having learned the patterns of language by ingesting vast swathes of text. Unlike the rest of the world, mathematicians were underwhelmed. But some researchers wondered whether ChatGPT's underlying architecture, a type of neural network called a transformer, might be made into a more mathematically literate tool. The problem is that transformers, for all their capacity to generate text, are notoriously useless at filtering out wrong answers or spotting their own mistakes. Or, as Williamson puts it, "they don't have a bullshit filter".

So when DeepMind researchers built FunSearch, the system that produced the best-yet solution to the cap set problem, they created an LLM to write solutions to maths problems in the form of computer programs and combined it with a system that ranks the programs by performance. Those that work best are then fed back to the LLM, which iterates improved versions until it discovers something new. "It worked a lot better than I thought it would," says Ellenberg, who worked with DeepMind to develop the system and collaborated with it to draw out fresh insights.

LES LIDDLE/SOLENT NEWS/SHUTTERSTOCK

An AI found a pattern resembling starling murmurations

A different DeepMind team has since repeated the trick. This time, a similar set-up called AlphaGeometry tackled complex geometry problems from the International Mathematical Olympiad (IMO), a competition for the world's brightest high school students. The IMO requires enormous mathematical creativity and AI systems have, historically, performed poorly when trying to answer its questions. But AlphaGeometry's transformer model, which had been trained on made-up geometry problems, combined with a logical checking system, performed almost as well as the best humans.

Many mathematicians reckon this kind of combination might yield further treasures. Some even suggest it might be the first hint of mathematical creativity, too. "It could be possible that this is what creativity is," says Williamson. "That a mathematician, like a poet or a musician or a novelist, just has a very good generational capacity and a very discerning evaluator."

But these latest breakthroughs also suggest a more tantalising possibility: if the generative part of a system was trained on a vast corpus of research-level maths, rather than the school-level problems of AlphaGeometry, it could plausibly begin to find proofs for existing conjectures and suggest entirely novel proofs and conjectures without the input of a human. Arguably, that would amount to something akin to human-level reasoning and understanding – to grasping the soul of the fact, as Poincaré put it.

The problem is that the vast majority of cutting-edge maths can't be read by a computer. The process of making it computer-readable, called formalisation, is tricky and time-consuming, and many mathematicians prefer to spend their time on the maths itself.

But formalisation is attracting more and more attention, not least because computer-assisted and computer-checked proofs are increasingly important in modern mathematics. Unlike in most other scientific disciplines, which test hypotheses through experiment and observation, mathematical knowledge is created through proofs. "Proofs are the centre of mathematics," says Emily Riehl at Johns Hopkins University in Maryland. "It is kind of what mathematics really is as a discipline."

Proof machines

When Andrew Wiles famously proved Fermat's last theorem in 1993, for example, he had to both discover and weave together cutting-edge results in number theory and algebraic geometry, which then spurred further research. But modern proofs, which can run to hundreds of pages, have also increasingly become a thorn in the side of mathematicians. Shinichi Mochizuki's dense and impenetrable 500-page proof of the abc conjecture, another number theory problem, is yet to be verified despite being released in 2012.

Machines can help. Not only can they quickly check whether a proof is correct, they

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can also help mathematicians write their proofs. Until recently, the only major formalised proofs have trailed far behind current research and aren't particularly useful for AI. But that is beginning to change. The idea is that if we can formalise enough proofs so AIs can access them, we could train these systems such that they can themselves generate conjectures and proofs more quickly, and maybe even more effectively, than we can. That way, AIs could learn to reason via mathematical thinking.

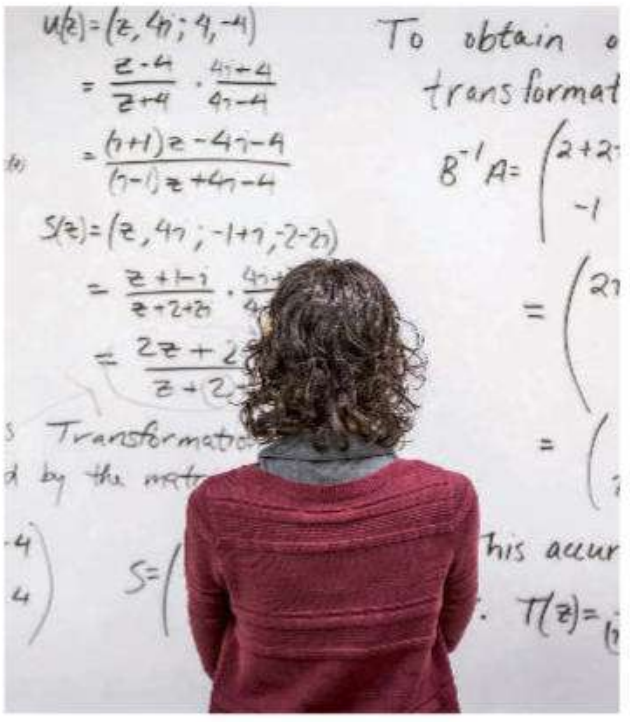
In 2022, Peter Scholze at the University of Bonn in Germany, a recipient of the Fields medal, the highest honour in mathematics, joined forces with his colleagues to formalise a new piece of his research using a computer language called LEAN. The project, called the Liquid Tensor Experiment, was completed in around two years and involved a new computer language invented by Scholze to describe topology, which concerns surfaces like doughnuts and spheres, using something called condensed sets.

Since then, other leading mathematicians have formalised their new research in LEAN. Last year, they proved an important conjecture in a part of maths called combinatorics and formalised it in less than a month. The time gap between written and formalised proofs has shrunk from years to weeks.

That could be significant in terms of what AIs can do, says Kevin Buzzard at Imperial College London. "Once [AIs] start getting some ideas as to how mathematical objects or concepts work, because they're reading our math libraries and getting the hang of how humans are using them, then you can imagine that maybe they'll be able to prove things. But now there's the question, can they invent new concepts?" In other words, will they be capable of producing new mathematical insights – those rare bolts from the blue – without human input?

For many mathematicians, the answer is a flat no, either that or they say such a prospect is at least decades away. The understanding and reasoning that they rely on for insights is uniquely human, and nothing that AI has done to date indicates that this has changed. "We've seen no evidence of this so far," says Buzzard.

Even so, ever since they met for a Fields Medal symposium on the topic in 2022, many of the world's leading mathematicians have been engaged in a debate regarding the extent to which automation will change the nature of their work, and how they might have to adapt. Some are more concerned than others that AIs present an existential threat to their profession, with much seemingly dependent on the extent to which AIs can ever decide on what mathematical ideas are interesting.


HILL STREET STUDIOS/GETTY IMAGES

Mathematical reasoning is a key benchmark for AI

"The AI told us something we wouldn't have tried on our own"

What AIs that can tackle advanced maths mean for the progress of AI as a whole, on the other hand, is a very different question – and one that may have implications for us all. Most observers say this is still many years away. But there is a select group of believers, buoyed by the rapid advance in LLM capabilities and what they have seen of their mathematical achievements so far, that thinks human-level mathematical reasoning – and by extension a more general form of AI – might be much closer.

The logic is clear enough: if mathematics is the highest form of human reasoning, then an AI capable of doing it as well as the best human mathematicians, or even better, would represent a significant stride toward artificial general intelligence (AGI), which is usually taken to mean a human-level intelligence that can handle all kinds of tasks. "The more we can push in that direction of intelligence... the more we're moving towards AGI," says Davies, even if he is quick to point out that true AGI would require a broader range of skills than reasoning alone.

Christian Szegedy, a computer scientist at the recently formed company xAI who has worked on using AI to do maths and automatic formalisation, is more bullish. He believes that we could have a superhuman AI mathematician by 2026. "Now, with new AI methods, they are basically artificial intuition machines," he says. "They don't just replace human intuition but exceed it by a large margin."

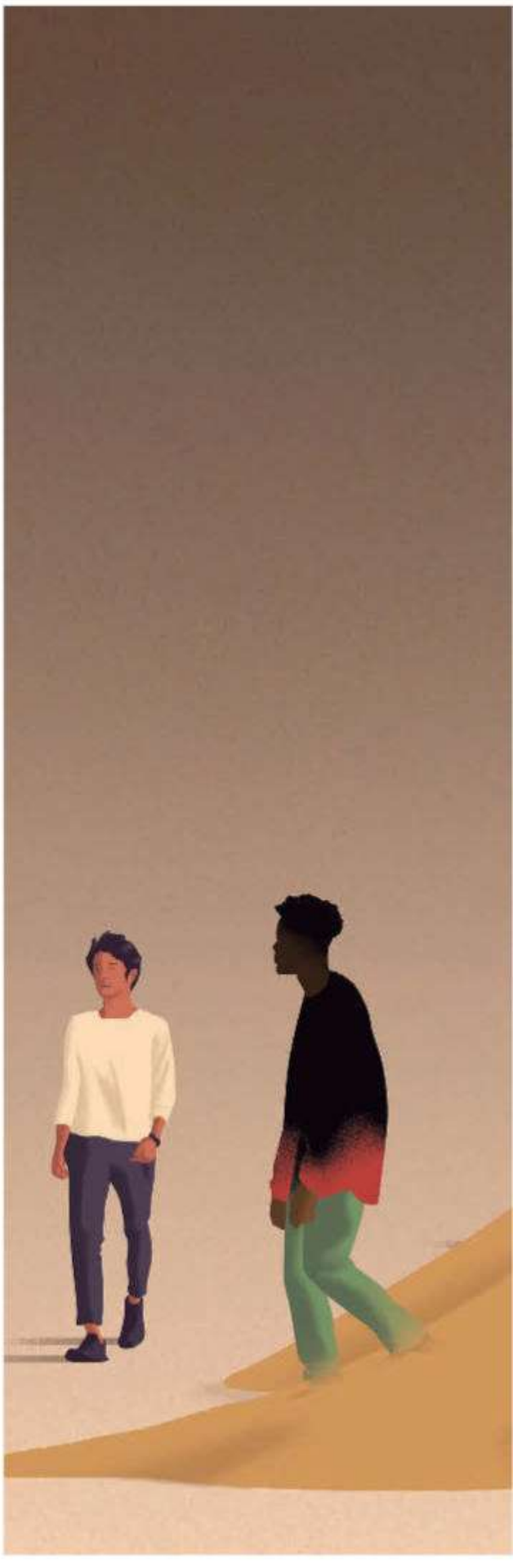
If Szegedy turns out to be right – and it remains a big if – then machine mathematicians might be taking us further down the line to AGI than many would care to admit. And even if not, the challenges presented by high-level maths are clearly pushing AI to new heights.

"Mathematics is extraordinarily capable of describing many aspects of our universe," says Williamson. "Suppose one had a system generally capable of answering difficult mathematics questions. Then such a system should also be generally capable of answering difficult questions about our world." ▮

Alex Wilkins is a news reporter at *New Scientist*

A stealth health crisis

One in three adults has a potentially dangerous fatty liver. Can more awareness avert a future epidemic, asks **Graham Lawton**



ANA YAEL

WHEN I was at school, I contracted viral hepatitis, despite never having done any of the things – sharing needles, getting tattooed or having multiple sexual partners – that are the usual risk factors for the disease. My biology teacher took one look at my sick and jaundiced face and told me, sagely, that "the life depends on the liver".

All I knew at the time was that life with a malfunctioning liver was pretty miserable. That, unfortunately, might now be the fate of an increasing number of people around the world. Liver diseases in general are on the rise, but one in particular is causing concern for doctors and researchers alike – and you have probably never even heard of it. More than a third of adults and around 13 per cent of children and adolescents are thought to have a condition known as non-alcoholic fatty liver disease (NAFLD), among other names – a condition that, if undiagnosed and untreated, puts them on a trajectory towards liver failure and a host of other conditions.

Not me, surely? Don't be complacent. Most people with NAFLD don't know they have it, as the condition is largely asymptomatic and screening programmes almost non-existent. But a concerted effort to raise awareness is under way in the hope of averting a crisis. The bad news is that, on our current trajectory, more than half of the world's adults will have NAFLD in their lifetime. The good news is that many of these people won't experience severe disease, and the rest may be able to reverse the problem – but only if it is caught early enough.

The liver is the largest internal organ in the human body and certainly earns its real estate. As well as being the main way that the body neutralises toxins, it also plays a vital role in immunity, digestion and vitamin storage.

Chronic liver disease isn't a new public health problem, but it has become a moving target. In the past, the main causes of a damaged liver were prolonged alcohol abuse and infection with hepatitis viruses, yet while these have declined due to increased awareness, widespread vaccination, needle exchanges and antiviral treatments, liver disease in general hasn't. The main reason for that is NAFLD.

The possibility of another, unknown, cause of chronic liver disease was first flagged in 1980, when Jurgen Ludwig and his colleagues at the Mayo Clinic in Rochester, Minnesota, published a report on what they called "a hitherto unnamed liver disease". They described 20 people with fatty accumulations in their livers similar to those seen in heavy drinkers; three had significant liver damage. The individuals were non-drinkers, but most were moderately obese. Ludwig and his colleagues dubbed it non-alcoholic steatohepatitis (NASH) (steatohepatitis means fat-related liver inflammation) and said it was of unknown cause. "Currently, we know of no effective therapy," they concluded.

The report went largely unnoticed for more than a decade. Unhealthy levels of fat in the liver were a known problem, but doctors saw alcohol as by far the most important cause. In the 1990s, however, the report came

> **“ The liver is having trouble functioning, but we’re not feeling it, and that’s a big problem**

to be widely cited as obesity rates rose and it became apparent that obesity was itself a cause of liver inflammation. NASH – by then widely known as NAFLD – was recognised as a distinct condition.

Today, NAFLD is the most common chronic liver disease in the world. According to a coalition of doctors called Healthy Livers, Healthy Lives, the worldwide prevalence in adults is 38 per cent and around 13 per cent in children and adolescents. That adds up to about 2.5 billion people.

“The prevalence of the disease has grown dramatically in recent decades,” says Jeffrey Lazarus at the City University of New York. “The numbers are huge.” In 1990, when fatty liver was starting to be considered as an important public health problem, it was estimated to affect 18.2 per cent of the global population. By 2020, that had more than doubled, and the number is expected to keep on rising. By 2040, more than half the adult population are forecast to have NAFLD, says Mindie Nguyen at Stanford University Medical Center in California.

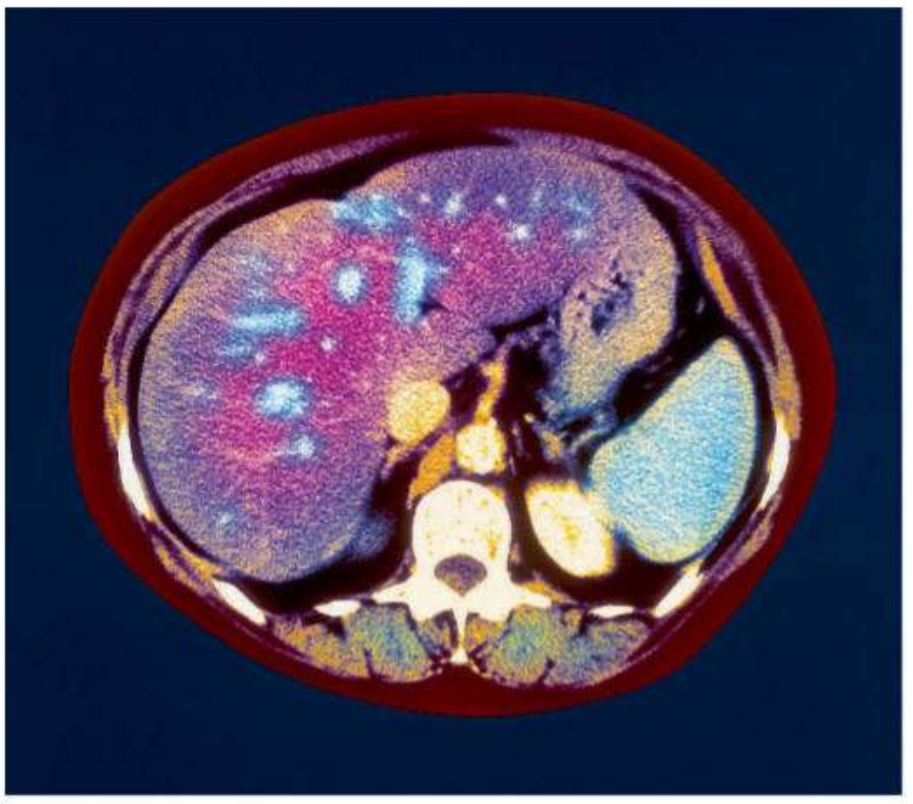
A growing problem

This doesn’t mean that all those people will feel physically ill, let alone be aware of their inflamed livers and declining hepatic health. NAFLD is largely asymptomatic beyond mild fatigue and a somewhat achy abdomen. But in around a third of people, the chronic inflammation associated with the condition gradually degrades liver function and can, if left untreated, spiral out of control.

The reason for the greater prevalence is pretty straightforward: there are an increasing number of people who are overweight or obese. Excess weight, particularly when coupled with type 2 diabetes, causes fat to accumulate in adipose cells in the liver. The fat content of a healthy liver is less than 5 per cent by mass. When it exceeds that, it has passed the threshold for NAFLD.

The prevalences of obesity, type 2 diabetes and NAFLD are rising in parallel across the world, according to Hannes Hagström at Karolinska University Hospital in Stockholm, Sweden. The World Health Organization says that obesity has nearly tripled since 1975 and that around 28 per cent of the global population are now overweight or obese.

But being a healthy weight isn’t a reason to relax. Around 10 per cent of people with NAFLD have a fatty liver despite their body mass index being in the normal range, a ›



SIMON FRASER/FREEMAN HOSPITAL, NEWCASTLE UPON TYNE/SCIENCE PHOTO LIBRARY

A cross-section of a liver with fatty deposits in blue

> **“Without national strategies in place, millions of people could develop some pretty awful conditions**

condition called lean NASH. The reason for this is poorly understood, although according to a 2022 review paper, it may be that some people have a genetic predisposition to accumulating liver fat.

Lean NASH not withstanding, NAFLD is largely a “comorbidity” of obesity, meaning that it is a secondary outcome of a primary health problem. Obesity’s better-known bedfellows are type 2 diabetes, cardiovascular disease, high blood pressure and cancer, all of which have been the subject of extensive public awareness campaigns.

NAFLD, however, has slipped under the radar, due to what Lazarus describes as “a generalised lack of urgency and policies to tackle the issue” along with low levels of public awareness. According to Lazarus, this is largely because it is so stealthy. “The liver is having trouble functioning, but we’re not feeling it, and that’s a big problem,” he says.

Other factors are involved in the neglect of NAFLD, according to Philip Newsome at the University of Birmingham, UK, and an adviser to the British Liver Trust. “There is a lot of stigma associated with liver disease. If you think about the commonest causes – namely excess alcohol, being overweight or obese, or, in the context of viral hepatitis, people that inject drugs – there is stigmatisation even in the profession,” he says. “And we know full well that when you stigmatise a condition, people are less likely to come forward, less likely to access care and, ultimately, it drives poorer outcomes.”

There is also limited availability of simple tests to monitor the progression of the disease, says Christopher Byrne at the University of Southampton, UK.

In 2022, a survey of 102 countries covering 86 per cent of the world’s population found that not one had a national strategy to address NAFLD. To judge this, the researchers created a “preparedness index” based on six criteria, including data collection, general awareness and the availability of diagnosis and treatment, then scored each country out of 100. India came top with 42.7 and the UK second with 40. But neither nation can be said to be well-prepared. “They failed, but everyone else failed worse,” says Lazarus.

More than a third of countries scored zero, including Ireland, Iceland and South Africa. Across the board, there is “substantial room for improvement”, says Byrne.

Without it, millions of people could develop some pretty awful conditions. What exactly happens after fat builds up in the liver is still a matter of debate, but the problem appears to be related to oxidative stress, which is where we see elevated levels of reactive oxygen species – molecules that cause damage to lipids, proteins and DNA. Oxidative stress seems to build up when fat in the liver is used as an energy source. This subsequently causes inflammation to occur.

For the unlucky ones, the result is fibrosis, the accumulation of tough scar tissue as the liver fights a losing battle against inflammation.

The liver has incredible powers of regeneration, with the ability to regrow completely after 90 per cent of it has been removed or damaged. But it has its limits. When scar tissue overwhelms the organ, the result is cirrhosis, which often leads to cancer and liver failure. The symptoms of cirrhosis include jaundice, tiredness and weakness, loss of appetite, weight loss, nausea and vomiting, pain in the right side of the abdomen, itchy skin and swelling of the feet and ankles. Around 80 per cent of people diagnosed with it die within a year.

Cirrhosis has also been increasing steadily. Between 2010 and 2019, the number of deaths rose by 10 per cent globally. Only about a tenth of those deaths were caused by NAFLD – the majority are still triggered by the hepatitis B and C viruses and alcohol – but whereas viral and alcoholic cirrhosis are gradually declining due to vaccination and alcohol control measures, NAFLD cirrhosis is on the up.

People with NAFLD don’t just have to worry about their livers packing up. The leading cause of death in this group is cardiovascular disease. It is also an independent risk factor for type 2 diabetes, chronic kidney disease and cancers in organs other than the liver.

Fortunately, NAFLD is eminently treatable if caught early enough. “It’s a terrifying situation, but it’s a very fixable situation,” says Lazarus.

A FibroScan could spot signs of fatty liver disease

BELMONTE/SCIENCE PHOTO LIBRARY

"For the vast majority, 75 to 80 per cent, at the lower stages of liver disease, we can intervene." Just last month, the US Food and Drug Administration approved its first drug that could help people with NAFLD, called resmetirom, which reduces scar tissue and other markers of poor liver health – and there are others in the pipeline.

Turning the tide

Meanwhile, lifestyle interventions offer a key solution. The slow burn of NAFLD and the early stages of fibrosis can be arrested or even reversed by losing 7 to 10 per cent of body weight and keeping it off, according to Lazarus. Of course, people who are overweight or obese have probably been told that weight loss would improve their health already, but if they knew they also had a potentially fatal liver disease, that might be extra motivation, he says. The problem is, people generally don't know because they aren't tested.

For that reason, Lazarus and others are making a concerted push to drag the disease up the public health agenda. In February, a consortium of more than 40 researchers, led by Lazarus, published a major call to arms titled "A global action agenda for turning the tide on fatty liver disease".

Part of that agenda is to rename NAFLD as – deep breath – metabolic dysfunction-associated steatotic liver disease, or MASLD, pronounced "mass LD". One major reason why is that the current name just adds to the stigma already attached to liver disease, with its allusions to both alcohol and fat. "The change in name was in part to make it something that people were more comfortable talking about," says Newsome.

Armed with the new name, the plan is to boost awareness of the condition and its causes, and to push for better screening programmes. According to Patrick Marcellin at the Paris Diderot University in France, the condition meets all the established criteria for routine screening, but almost nowhere actually does it.

It can be done: there is a blood test called the enhanced liver fibrosis test, which measures three molecules involved in metabolism that reflect the severity of liver fibrosis. But it is expensive. A cheaper alternative is FIB-4, which calculates the chance of a person having fibrosis from routine blood test results. "It gives an indication that something might be going on," says Lazarus. A relatively cheap ultrasound test called a FibroScan, which can detect both fibrosis and cirrhosis, can be used to follow up.

A trial in Scotland in 2019 was so successful that National Health Service Tayside in Dundee now carries out routine screening. But very few health systems have followed suit, says Lazarus. "If I were in charge, I'd be putting FibroScans everywhere."

Not so fast, say critics. Mass screening is controversial. You want to avoid missing people who are going to develop significant disease, says Newsome, but you also want to avoid chasing those who ultimately aren't going to develop a liver problem. "It raises anxiety. It consumes resources." Much better to target those who are known to be at high risk, such as people who are overweight or obese and have type 2 diabetes.

What would really help, says Newsome, is to understand why some people are more susceptible to ending up with more severe liver damage than others. "You can often have two patients the same age, same weight, and both have diabetes, but one will have significant scarring and the other won't," says Newsome. Exactly why is unclear, though there are strong signs that it is genetic, he says.

Soon there may be tests that identify who is most at risk of scarring, but screening can't solve the problem on its own. As we know well, there are many factors that affect people's weight, such as genetics, hormonal changes and age, as well as lifestyle and economic factors that aren't necessarily within their control. People also have to act on any advice or support given, which, as experience of trying to halt the epidemic of obesity and type 2 diabetes has shown, can be incredibly challenging. "Most of the strategies to deal with this have failed," says Newsome. The new generation of weight-loss drugs, such as Wegovy, may help, he says.

In the absence of screening, it is probably better to be safe than sorry. Newsome's advice is that if you think you may be at risk, ask your doctor for a test. But ultimately, the take-home message is obvious: maintain a healthy body weight. Easier said than done in our obesity-promoting environment, but as that wise teacher told me, the life depends on the liver. ▮

"Around 10 per cent of people with fatty liver disease aren't overweight

DON HEUPEL/ASSOCIATED PRESS/ALAMY

For the vast majority of people, lifestyle interventions can reverse the risk of fatty liver disease

Graham Lawton is a features writer at *New Scientist*

How not to languish

Do you feel aimless and numb inside? Is it hard to pinpoint what's wrong? You may be languishing, says **Corey Keyes**. He tells Grace Wade how to turn this around and flourish

Like many people, my mental health took an enormous hit during the covid-19 pandemic. I felt lonely and lost, unsure of the direction of my life. Mundane tasks like making my bed became overwhelming, and I was uninterested in activities that once brought me joy. I wasn't sad, but I wasn't happy either. I was just… existing.

Actually, I may have been languishing, says Corey Keyes, a psychologist at Emory University in Georgia and advisor to the World Happiness Report. Keyes has dedicated his career to understanding this particular state of mind and, crucially, how to avoid it.

In his new book, *Languishing: How to feel alive again in a world that wears us down*, Keyes argues that while mental illness is a problem, so is the absence of mental well-being. He spoke with *New Scientist* about what languishing is, why it is a concern and how we can all work towards flourishing instead.

Grace Wade: What is languishing?

Corey Keyes: Languishing is the absence of well-being. It is when people feel they have nothing positive going on in their lives. No meaning. No mattering. No warm, trusting relationships. No happiness or joy. Yet it doesn't necessarily mean negative emotions like sadness or fear. People who are languishing almost feel nothing. They describe it as being numb or dead inside. I call languishing the neglected middle child of mental health, since it falls between mental illness and mental well-being.

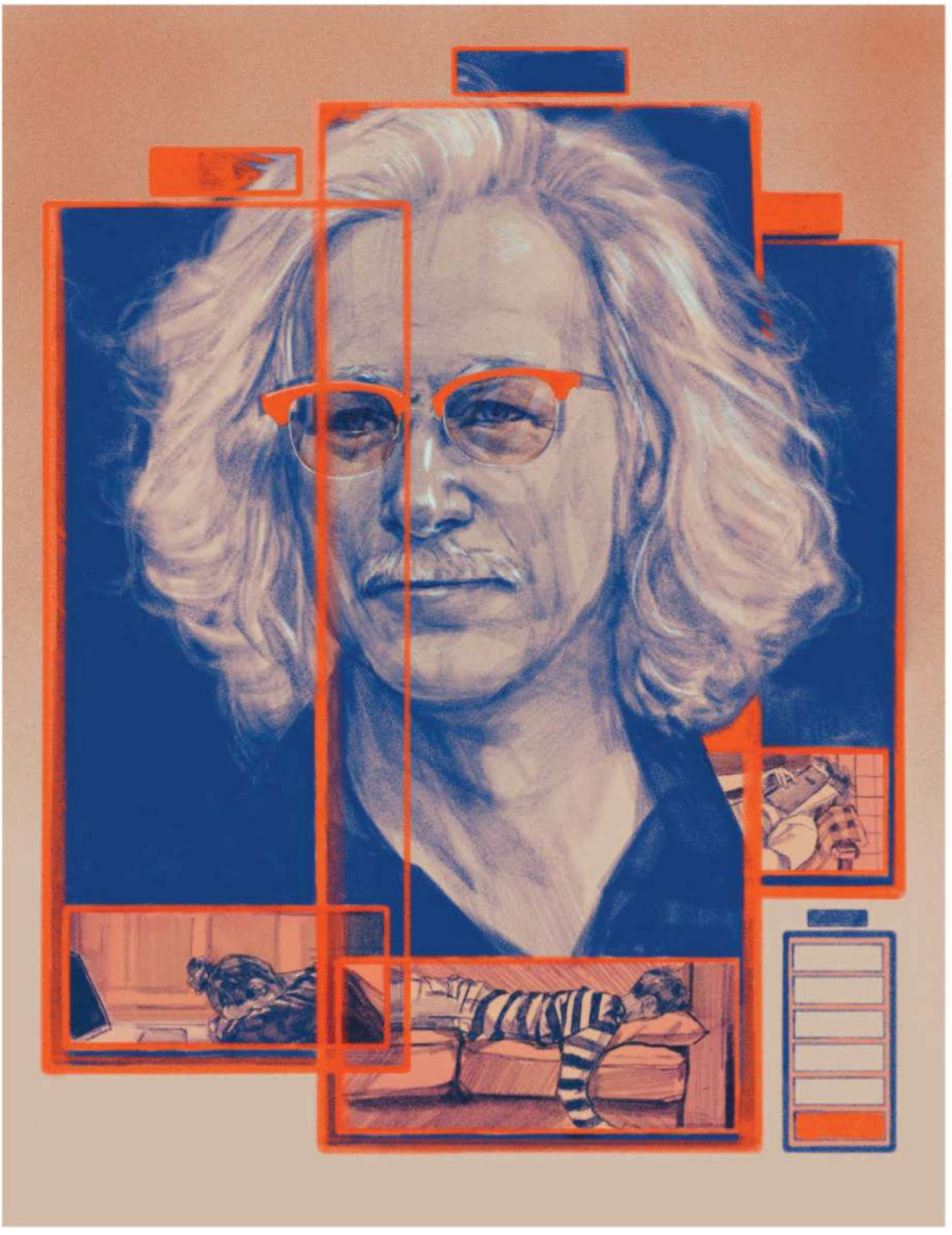
How is languishing different to depression?

Only one symptom overlaps between depression and languishing, and that is a loss of interest in life. The remaining signs of depression are all about sadness or malfunctioning on a daily basis: you sleep too much or too little, eat too much or too little and you might have suicidal thoughts. Depression is defined by negative symptoms, whereas languishing is characterised by the absence of positive ones.

Some people's descriptions of depression may fit languishing because it is possible to be depressed and languishing at the same time. That isn't to say they are the same thing.

How can someone be languishing and depressed at the same time?

My research has shown that mental wellness actually exists on two dimensions: mental illness and mental health. People can have no mental illness and poor mental health – ›



ULA ŠVEIKAUSKAITĖ

in other words, they are languishing yet don't have a mental health condition. Or they can have a mental illness and high mental health. For instance, someone with bipolar disorder can still feel happy, interested in life and have warm, trusting relationships. You can also have poor mental health and a mental illness simultaneously.

Is it possible that people attribute languishing to depression because they don't know how else to describe how they feel?
Certainly. People who fit the criteria for languishing often seek traditional mental health treatments. My hunch is that many people who are languishing are swept into the wrong category because it is simply assumed they have depression. Or they are swept under the rug and told they are fine, even though they feel something is wrong.

We tend to think the opposite of depression is flourishing, but the evidence suggests that isn't true. Treating depression doesn't mean someone will regain their full mental health. They may still languish, which increases the risk of them relapsing back into mental illness.

Is there a way to assess if you are languishing?
About 25 years ago, I developed a 14-item questionnaire that assesses mental well-being, or what I call flourishing. It asks questions across three domains: emotional, psychological and social well-being. Things like, how often do you feel satisfied in life? Do you feel you belong to a community? Does your life have meaning or purpose?

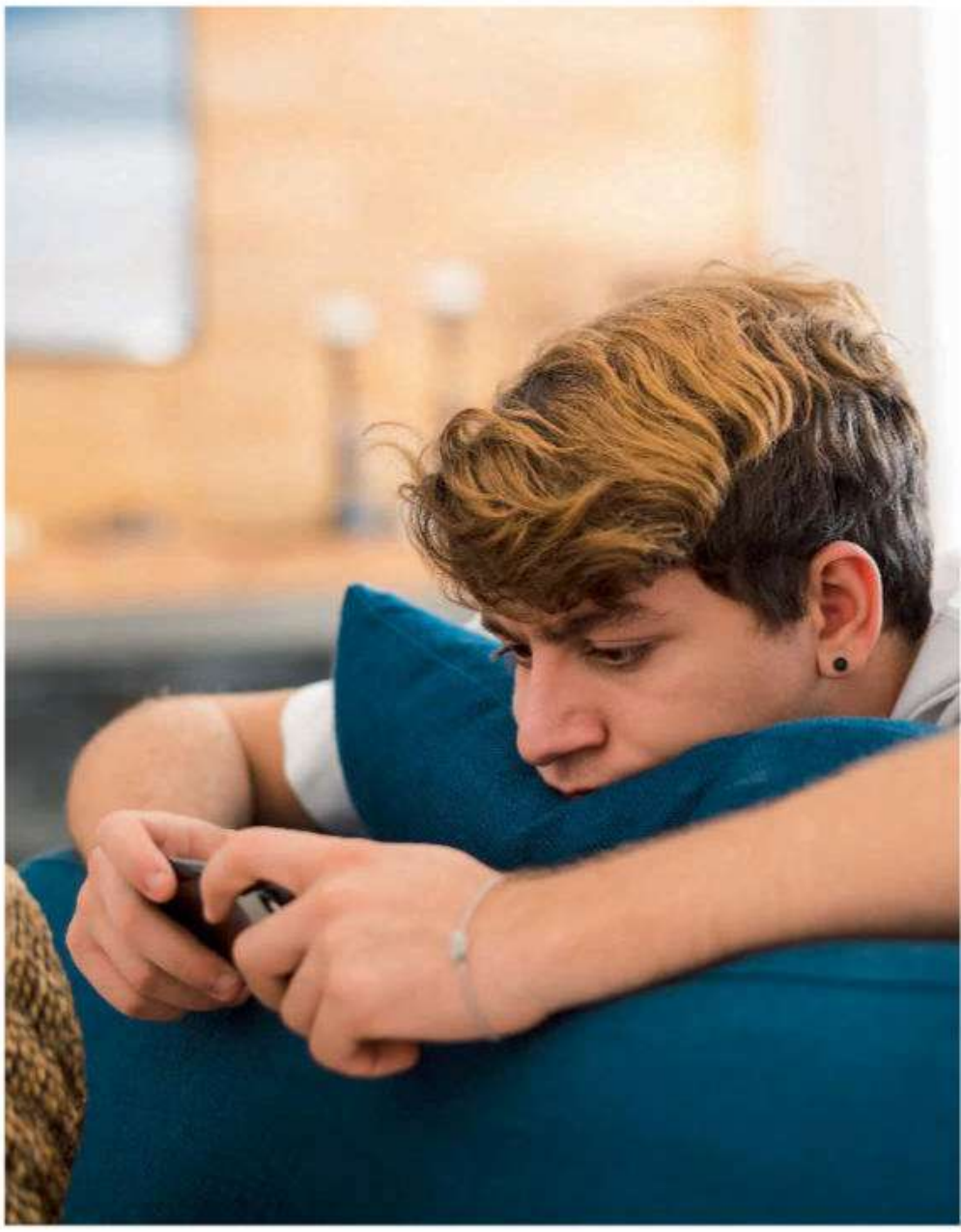
People with low scores on at least half of the questions are considered to be languishing. This has been validated in many different cohorts of people across the world from the US and Europe to South Africa and Asia. There is now a robust body of evidence showing this measure is distinct from depression.

Isn't it a normal part of life to sometimes feel this way, though?
I am prepared for the inevitable criticism that says I am pathologising a normal part of life. Yes, languishing is normal. So are sadness and fear. But normal doesn't mean you must stay there and wallow in it. When you are sad for an extended period, you start slipping into mental illness. The same is true for languishing. Studies show that about 40 per cent of teenagers in the US are languishing, so it is normal to a degree. But when kids languish for too long, it becomes dangerous. They start engaging in risky behaviours, like experimenting with drugs, and are more likely to drop out of school.

Think of it like a stagnant stream. If water stops flowing for too long, scum and algae begin to form. People who languish feel stagnant, too. They are not growing, and humans are meant to grow.

What happens if people languish for a long time?
Languishing is the equivalent of being mentally unhealthy, similar to how unhealthy physical habits like not exercising enough or eating too much junk food can lead to illness.

People who languish are less productive at work. Research has shown that languishing may leave us vulnerable to developing depression, post-traumatic stress disorder and suicidal thoughts. It might also raise the risk of premature death. Plus, languishing exacerbates mental illness. People who are depressed and severely languishing have the highest risk of attempting suicide, for instance.



Around 40 per cent of teenagers in the US are languishing (right). Getting involved in a community project and learning to play an instrument (far right) are two ways to help reverse the feeling.

CLOCKWISE FROM LEFT: POLLYANA VENTURA/GETTY IMAGES; JEFFREY ISAAC GREENBERG 2+/ALAMY; YAHYA ARHAB/EPA-EFE/SHUTTERSTOCK

What can people do to help themselves flourish?
There are five activities that research shows help people feel more joy, gratitude, hope and other positive emotions. I call them the five vitamins. These are: helping others, learning something new, playing, engaging in spiritual or religious practices and socialising. Not only will you have a better day if you choose to participate in these activities, but you will also slowly move out of languishing and closer towards flourishing.

Could you give some examples of activities that help overcome languishing?
When it comes to helping others, simply buying someone coffee or helping your neighbour carry their groceries inside isn't enough. That is nice, but it has to be a slightly deeper commitment. The ultimate goal is finding your purpose in life. The idea is to leave the world a better place in your own unique way. Having a purpose is deeply protective – it keeps you going when life gets tough or when you must make sacrifices.

Some people are lucky enough to experience

this through their careers. But this is rare – only about a third of people find purpose in their work. Most people find it elsewhere. I would suggest starting small. Keep it local. Often, volunteering one day a week for a couple of hours is sufficient. Or maybe try coaching a local youth sports team or tutoring students.

What else?

The second "vitamin" is learning something new. This isn't about building a skill for immediate economic or practical value. It is about building a skill to grow and improve, which feels good. And this can be learning an instrument, taking up painting or starting to garden.

For play, I essentially mean playing games. A good game creates a sense of accomplishment and helps people view themselves as a source of cause and effect. It helps them realise that what they do matters because what they do has consequences. But it doesn't have to be a game in the traditional sense. Writers and artists play with ideas. You can also take everyday, mundane tasks and turn them into a game. For me, it is creating lines or artwork in the grass when I am mowing my lawn.

What sorts of activities help with the final two "vitamins"?

Engaging in spiritual or religious practices is important because we need something or someone beyond us to help encourage us, especially when we feel weak, to become stronger and do the right thing. What is there to guide you towards becoming a better person? If religion and spirituality don't click with you, then I suggest turning to philosophy – something that allows you to practise ways of thinking and behaving in a world where you need to understand what you can and can't control.

The last vitamin is about socialising. We are finally understanding that loneliness can be detrimental. It turns out the absence central to languishing involves three things linked to loneliness. One is the absence of warm, trusting relationships. Second is not belonging to a community and the third is not contributing to a community. The way to address this isn't more connections, but enhancing the quality of connections. You must find your community, or your home away from home. Then you must develop relationships where there is trust, vulnerability, reciprocity and affection.

How long does it take for these activities to relieve languishing?

There is no research on a specific timeline. Longitudinal studies have looked at the effects over a few months and it doesn't take long to see some benefit. The activities are about improving your day, and you don't have to do all five every day. Usually, people just need to choose one a day and they will feel better than if they had done none.

The only way to stay flourishing is to remain committed to these habits. If you stop, you will start slipping back towards languishing. So, make them part of your daily or weekly routine.

Is flourishing the same as being successful?

No, at least not in the way society tends to define success – an impressive career, good grades, wealth. Success in that sense can actually be destructive.

For instance, a study of US college students found that those who are Asian-American are more likely to languish than those from other racial or ethnic groups. This is despite the fact that Asian-Americans have the highest median household income and tend to have higher-status jobs. But I think that is part of the problem. The determination and pressure to succeed is so strong that I suspect it requires sacrificing many things, including well-being.

This is why intention matters when practising the five vitamins. Don't practise them because you want to get better at them than other people. Fix your intention inward, on learning about yourself and becoming a better person. ▮

> "There are five activities that help people feel more hope, joy, gratitude and other positive emotions"

Need a listening ear? UK Samaritans: 116123 (samaritans.org); US 988 Suicide & Crisis Lifeline: 988 (988lifeline.org). Visit bit.ly/SuicideHelplines for other countries.

Grace Wade is a health reporter for *New Scientist*

The back pages

Puzzles
Try our crossword, quick quiz and logic puzzle p45

***Almost* the last word**
How did Stonehenge creators measure the length of a day? p46

Tom Gauld for *New Scientist*
A cartoonist's take on the world p47

Feedback
Chasing tales, plus a cuppa cure and seeds of doubt p48

Twisteddoodles for *New Scientist*
Picturing the lighter side of life p48

60-second psychology

Reaching the peak

My column about the spiritual side of science has seen many of you sharing your own awe-inspiring experiences, says **David Robson**

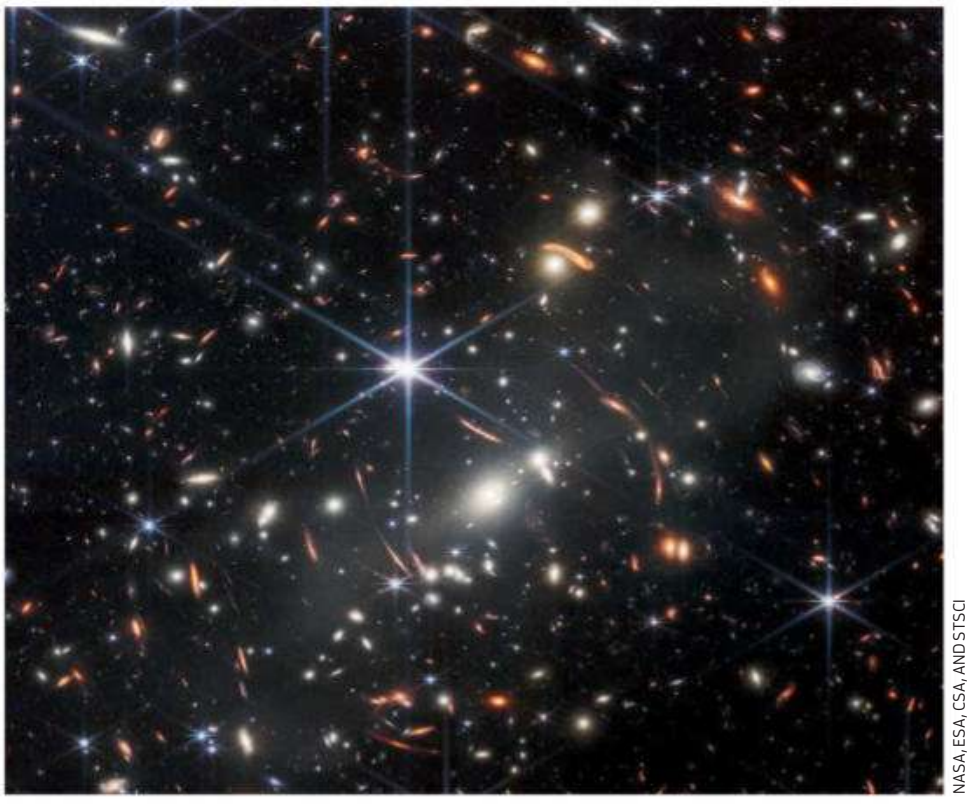
David Robson is an award-winning science writer and author of *The Laws of Connection: 13 social strategies that will transform your life*, out on 6 June

IN THE middle of the last century, the psychologist Abraham Maslow set about investigating the foundations of happiness. Interviewing people about their lives, he was intrigued to find that many reported having experienced rare moments of epiphany, associated with "awe... rapture, ecstasy or bliss" in which "all separateness or distance from the world disappeared".

Those feelings were often accompanied by a sense of great understanding, Maslow said – "the feeling that they had seen the ultimate truth, the essence of things". He described these as "peak experiences", and subsequent research confirms these moments can contribute to long-term well-being. Whether we are triggered by religion, art, music or nature, it pays for our minds to transcend the here and now, at least occasionally.

In my previous column, I wrote about the "spirituality of science", and I have loved hearing your stories, many of which resemble Maslow's peak experiences.

Consider the following account by Jenny Larby, who remembers a chemistry lesson about entropy. "My mind was completely blown – the simple idea that disorder was more likely than order, explained so much about our messy world," she writes. "I could suddenly see everything around me differently, and chaotic or unexplainable things felt somehow more acceptable. I felt like I'd discovered the key to the universe."



NASA, ESA, CSA, AND STSCI

Another reader described a maths lesson where she learned about Euler's identity, which connects five fundamental numbers in a single equation: $e^{i\pi} + 1 = 0$. Like Larby, this reader spoke of feelings of wonder. "Maths is extraordinary. The universe is extraordinary. Human minds invented all this abstract symbolic stuff and it turns out to fit the world out there." I wholeheartedly agree; discovering Euler's identity persuaded me to study maths at university.

For some readers, such as Paul Kemp, peak experiences have become a regular occurrence. He reports feeling inspired by images from the James Webb Space Telescope "showing thousands of galaxies in a tiny area of sky" (pictured) and by elephants burying their young. "No deity is needed to see the true wonders of the universe we live in and new examples come in almost daily," he says.

The excitement can manifest as an intense urge to share what we know. "Often I jump out of my chair, start walking around and I want to tell the whole world about my new idea or scientific finding," says Onno Hamburger, a psychologist in the Netherlands.

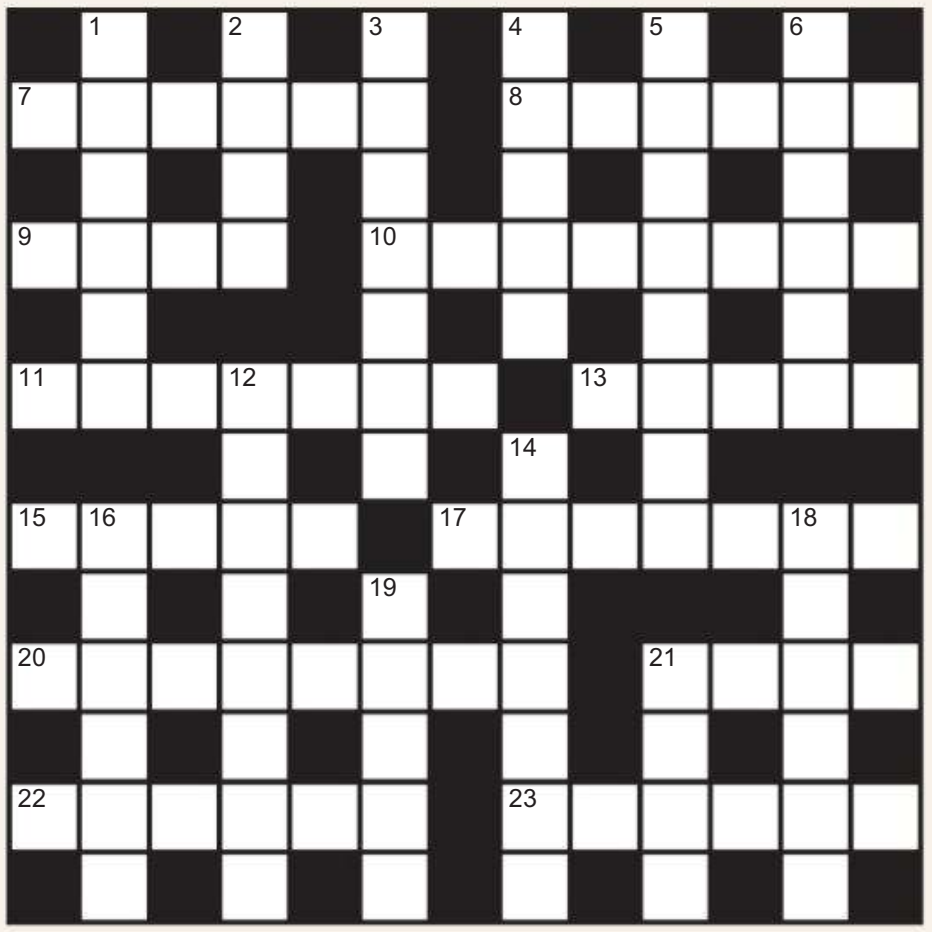
I would like to say a huge thank you to everyone who got in touch. It is truly amazing to see the emotions that science can inspire and the sense of connection that comes from our curiosity about the world around us. ▮

These articles are posted each week at newscientist.com/maker

60-second psychology appears monthly

Next week
Stargazing at home

Cryptic crossword #133 *Set by Trurl*



Scribble zone

Answers and the next quick crossword next week

ACROSS

7 Story collection, one to steal from set of old books (1,5)
8 Be contained, not "out there" (6)
9 Fluid motion resulting from illness unknown (4)
10 Earth scientist with zero hair! (8)
11 From Latin, some information about elements in museum display (7)
13 Unprecedented achievement for Lionheart or Conqueror, possibly (5)
15 Medieval ventilator contains release mechanism (5)
17 Lead once, showing purple bottom (7)
20 I'm appreciative, compared with state of ungrateful leaders (5,3)
21 You can do it in among co-workers or out in a stable (4)
22 Whosoever might be annoyed should ultimately cut loose (6)
23 Spike's in feline family (6)

DOWN

1 Chatty expert's very nearly sixty (6)
2 I live to kiss horny mountaineer (4)
3 "Gaia" lot going around causing earache (7)
4 Strain to see First Lady carrying sacred arrowheads (5)
5 Hamill cast with leads from *Unbreakable* and *Thunderbirds* – metal! (8)
6 King, we hear, in ruins (6)
12 Incomplete list provided by one who makes things up (8)
14 Flamboyantly go for liquid measure (7)
16 Shatner almost lost in European capital (6)
18 Wretched child's primitive facial feature (6)
19 Tenth fire claiming "fireproof" stuff (5)
21 Small child with great strength, it's said (4)

Our crosswords are now solvable online
newscientist.com/crosswords

Quick quiz #247
set by Bethan Ackerley

1 The temperature above which certain materials lose their permanent magnetic properties is named after which scientist?

2 The doughnut-shaped belts of radiation surrounding Earth are named after which physicist?

3 What name is given to the dividing groove down the middle of the tongue?

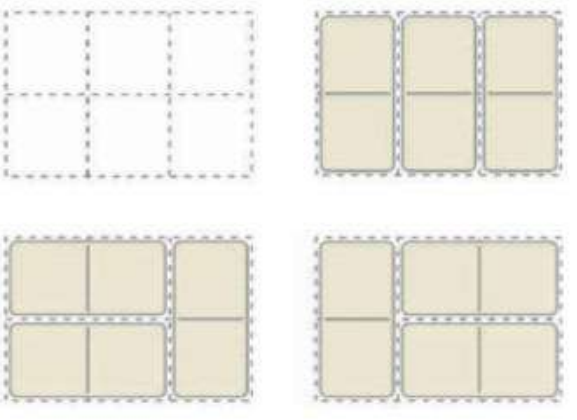
4 The Hayabusa mission, launched in 2003, brought back material from which asteroid?

5 On which island would you find Mount Tambora, which in 1815 was the site of one of the largest volcanic eruptions in recorded history?

Answers on page 47

BrainTwister
set by Peter Rowlett
#15 Domino strips

There are three ways to cover a 3 × 2 grid with dominoes.



How many ways are there to cover a 4 × 2 grid? What about a 6 × 2 grid?

Can you find a pattern that would help you work out the number of different ways dominoes can be used to cover any n × 2 rectangle?

Solution next week

Timing it right

If Stonehenge is a giant calendar, how did the ancient Britons measure the length of days precisely enough to put the Heel Stone in just the right place to mark the solstices?

Eric Kvaalen
Les Essarts-le-Roi, France
They didn't need to measure the length of the day. The solstices are the days when the sun rises the furthest north and the furthest south (in June and December respectively in the northern hemisphere). So they would simply observe where the furthest north or south sunrise happened.

Hillary Shaw
Newport, Shropshire, UK
This doesn't require clocks, or any idea of what the sun is or why it appears to move. Farmers needed to know the day and the season to know when to plant, rather than hours or minutes. They would have observed that the sun (and moon) rose and set in different places each day, reaching different elevations. They could have then tracked and measured the minimum length of the sun's shadow, cast by a fixed marker,

"Foretelling events like eclipses to peasant farmers would have proved priests' power to commune with gods"

and against what horizon landmarks it rose and set, from a fixed observation point. Members of the leisured priest-astronomer class would have measured and counted the days.

Over time, they would have seen, even with some observations missing due to clouds and some minor perturbations due to variable atmospheric refraction, a basic 182/183-day rhythm of sunset drifting east then west, plus the minimum-length shadow getting longer and shorter.

SHUTTERSTOCK/M-PRODUCTION

This week's new questions

Playing it cool **Is it more efficient to leave the fridge briefly open when I am pouring milk for my tea or to close and reopen it, given that warm air is introduced whenever the door is opened?** ***Michael Paine****, Beacon Hill, Australia*

Clever question **Once life is established, is the evolution of intelligence inevitable?** ***Matthew Wenban-Smith****, London, UK*

Cleverer priests would have noted that the moon was sometimes higher than the sun, sometimes lower, and it sometimes crossed the sun's sky-path. Over time, it would have been possible to work out when a solar or lunar eclipse was due. Foretelling these events to uninformed peasant farmers would have proved their exclusive power of communing with the gods.

David Bortin
Whittier, California, US
The consensus seems to be that the most likely way of determining the solstices (literally "sun stands still") and equinoxes ("equal night") would have been to wedge a stick in the ground and then, every day for a year, place a pebble at the end of the stick's shadow.

One problem is that it is hard to keep pebbles on the ground from being accidentally kicked or otherwise moved about. Solution: replace them with giant stones.

Nath Rao
Via email
I am reminded of a description of how the Kalash Indigenous people of Pakistan determine the date of their winter solstice festival. The people in charge watch the sunrise each day, and when the point of sunrise is at a mark they have determined before, they declare the festival to be on.

David Perryman
Via Facebook
It would have been pretty obvious where to put the Heel Stone if they had been paying attention.

Want to send us a question or answer?
Email us at lastword@newscientist.com
Questions should be about everyday science phenomena
Full terms and conditions at newscientist.com/lw-terms

Should you leave your fridge open when briefly pouring milk into tea or close and reopen it?

"Oi, Aglain, what's the furthest right you said you saw the sun come up?"

"That tree over there, Terry."

"Go over there a bit then and I'll tell you when you're in front of it. That's where we'll put that rock."

What is more interesting is why we think it is amazing. Just because we are distracted from marking where on the horizon the sun comes up, it doesn't mean ancient people were.

Whale song

Is there any prospect of using machine learning to converse with whales and dolphins?

Mike Follows
Sutton Coldfield, West Midlands, UK
Douglas Adams dreamed up an organic universal translator called a Babel fish that could be popped into your ear. Though it is amazing how prescient science fiction can be, this won't become a reality in the near future, if ever.

Communicating with other animals like whales and dolphins is challenging because we don't have the equivalent of the Rosetta Stone, which would allow for direct translation. Decrees in ancient Egypt were inscribed onto stelae, essentially slabs of stone. Part of one stele was discovered in 1799. Now known as the Rosetta Stone, this was key to deciphering Egyptian hieroglyphs because the same information was also written in ancient Greek and Demotic scripts.

However, it has recently become clear that words in a language can be represented by their location in three-dimensional space using techniques in natural language processing like word2vec. Words with a similar meaning are grouped together in natural language processing.

It turns out that every language can be represented by a very

Tom Gauld
for New Scientist

ASTRID MAY NOT HAVE BEEN THE MOST SENIOR, NOR THE MOST EMINENT, ASTROPHYSICIST WORKING AT THE INSTITUTE, BUT SHE WAS UNDOUBTEDLY THE ONLY ONE ORBITED BY A SMALL, ROCKY MOON.

similar three-dimensional shape and these shapes can be made to occupy virtually the same space by rotating them so that the word for "dog", say, is in the same coordinates no matter the language. Subtracting the coordinates for "face" from "smiley face" would give "smiley", for example. Could the same be true of animal "languages"?

This would support the notion that there is a universal hidden mathematical structure underlying everything, including communication, an idea discussed by theoretical physicist Eugene Wigner in his 1960 paper "The unreasonable effectiveness of mathematics in the natural sciences", something that is simultaneously breathtaking and slightly alarming.

Although animals experience a different "culture", they share much of the same self-awareness and many of the emotional responses that we take for granted, which increases the chance that we may be able to communicate with them one day.

"If I were Doctor Dolittle, I might ask an orca why they have adopted the habit of ramming and disabling yachts"

In the same way that the telescope displaced Earth from the centre of the universe, machine learning might eventually let us communicate with other species. Hopefully, this would encourage greater humility among *Homo sapiens* and help us understand that we need to live in better harmony with the natural world.

However, there are ethical issues. Researchers might be tempted to use artificial intelligence to produce synthetic communication with wild animals. Part of the problem with this is that, initially at least, we wouldn't understand what the chatbots were saying on our behalf. There is a danger this could disrupt natural communications, like the songs produced by humpback whales. For this reason, scientists should perhaps start by only communicating with captive animals.

Maybe some species are ahead of us. After all, the team behind the *Blue Planet II* documentary filmed false killer whales and common bottlenose dolphins hunting and socialising together in a superpod in the Hauraki Gulf, New Zealand, and they seemed to communicate with each other in a third language. Though there are more pressing questions, if I were Doctor Dolittle, I might ask an orca why they have adopted the habit of ramming and disabling yachts.

Best thing since

What is the best way, and best knife to use, to minimise crumbs when slicing bread, particularly wholemeal? (continued)

Guy Cox
Sydney, Australia
Richard Miller suggests using an industrial laser cutter to slice bread. Surely if you did this, you would end up with toast, not a fresh slice of bread? ▮

Answers

Quick quiz #247 *Answers*

1 Pierre Curie
2 James Van Allen
3 The median sulcus
4 Itokawa
5 Sumbawa, Indonesia

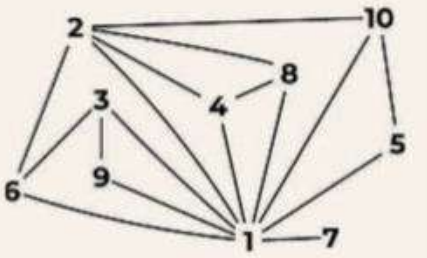
Quick crossword #155 *Answers*

ACROSS 9 Halogen, **10** Hahnium, **11** Off-peak, **12** Ice floe, **13** Synthesis, **15** Magma, **16** Termini, **19** Wattage, **20** Angle, **21** Myoglobin, **25** Audubon, **26** Lactose, **28** At first, **29** Neutral

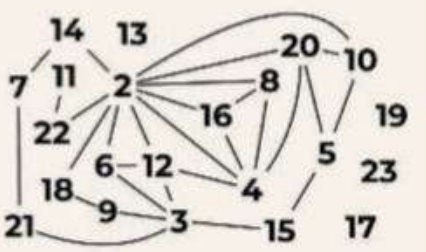
DOWN 1 Throbs, **2** Olefin, **3** Ogee, **4** Snakes, **5** Chainsaw, **6** Sheet metal, **7** Diplegia, **8** Amperage, **14** Heidelberg, **16** Tuataras, **17** Rigidify, **18** Immunity, **22** Online, **23** Bio art, **24** Needle, **27** Caul

#14 Factor graphs *Solution*

Here's a factor graph of 1-10:



You can connect every number up to 14, but adding 15 requires drawing lines to 3 and 5, which leads to crossing. If we exclude 1, you can add every number up to 23 (see below – some prime numbers now require no lines), but 24 has too many factors.



Chasing the tale

Silvia Leonetti and colleagues in the Netherlands, Italy, Austria, the US and Denmark don't quite explain why dogs wag their tails, but they do explain that it is hard to explain.

In a paper called "Why do dogs wag their tails?" in *Biology Letters*, these dog-tail contemplators confront one, presumably easier, sub-question: "why [do] dogs wag their tails more frequently and in more contexts than other closely related canids, such as wolves"?

This narrowed focus, they say, "serves as a starting point to propose empirical low-hanging fruits, recommendations and suitable methodologies for future studies". They offer generalised guesses that the increased wagging could result – maybe directly, but maybe indirectly – from evolving while living with humans. Finding the real answer to even this little piece of the wag story, they conclude (leaving lots of waggle room), will require "dedicated experiments that not only better quantify tail wagging in general but also explicitly consider how the behaviour is controlled".

Thus, as many people suspected, understanding why dogs wag their tails requires understanding why dogs wag their tails.

Donald Duck dam jubilee

We are just a year away from the jubilee – the 50th anniversary! – of the publication of the most beloved technical report ever written by a deputy director of design and construction for the US Department of the Interior's Bureau of Reclamation. That report, which perhaps needs no introduction, is "Construction of Grand Coulee [Dam's] Third Power Plant". Published in the *Journal of the Construction Division* in 1975, it was written by Donald J. Duck.

Duck, as his admirers well know, was based at the Bureau of Reclamation's facility in Denver, Colorado. (His name is familiar to many, perhaps due to the publicity from a lawsuit brought against Duck and the United States of America, and also against three of Duck's fellow government officials. The case concerned a directive to the plaintiff to repair a pipeline. A judge dismissed that lawsuit in 1980.)

Feedback suggests that you not procrastinate in preparing yourself and your family for the grand celebration.

Twisteddoodles *for New Scientist*

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or New Scientist, 9 Derry Street, London, W8 5HY
Consideration of items sent in the post will be delayed

Anti-covid tea gargling

The story of tea is now, in tiny part, the story of an attack – an attack by inanimate bits of tea on a virus that attacks humans: the coronavirus.

It is the story of "SARS-CoV-2 viral particles resuspended in saliva", where those particles are assaulted by one or another kind of tea commercially available in North America. Julianna Morris and Malak Esseili at the University of Georgia in the US mounted that tea onslaught. They describe this in their study, "Screening commercial tea for rapid inactivation of infectious SARS-CoV-2 in saliva".

The Morris/Esseili adventure, violent though it may be at a microscopic level, is part of a large, mostly placid, not especially coordinated international search to recognise and verify all the different effects that tea might have on… well, on everything.

Investigators are searching and testing for tea effects on the coronavirus in India, Japan, China, Austria and many other places. And the powers-of-tea quest grows ever wider in its hopes. Every new disease is a possible triumph-in-waiting for They Who Would Vanquish an Ailment with a Mighty Cupful or Potful.

Tea can invigorate, maybe. Tea can heal, maybe. Tea can rejuvenate, maybe. Tea can boost a person's intelligence. Maybe. Maybe tea can do anything. Maybe.

Every year, the world finds itself awash in thousands of new research studies about tea and its imagined effects. Where will it all lead? Morris and Esseili express their current, specific vision of how and why to deploy tea. They hope that someday "rapid at-home intervention (tea drinking or gargling) to reduce infectious SARS-CoV-2 load in the oral cavity… might also mitigate infection of the oral mucosa".

When the next new big disease comes down the turnpike, tea will be there to be hurled at it by researchers. Hope will brew eternal.

Just a wee experiment

An ounce of prevention was not worth a pound of cure in Jorge Castro's attempt "to find an easy to use, cheap, and universal substance to protect seeds against predators in forest restoration programs". *Restoration Ecology* published Castro's explanation of what went wrong. It is called "Human urine does not protect acorns against predation by the wood mouse (*Apodemus sylvaticus*): A field study with video recording".

Mark Benecke sent a copy to Feedback, who was relieved to learn that those videos – there are 1440 of them – deal mostly with the activity of the mice. Lots of pilfering of acorns, done artfully, quickly, efficiently.

Castro, at the University of Granada, Spain, came into this with two hypotheses. He came out of this deciding that only one of them is true: "that mice will be the main agent of acorn removal".

The experiment showed, he says, that the other hypothesis – "that human urine will repel wood mice" – is false. Furthermore, he worries, it may be worse than false. Citing a 2002 paper, he warns that: "If the mice do not perceive humans as a danger, our scent could actually have the opposite effect than expected." ▮

Marc Abrahams

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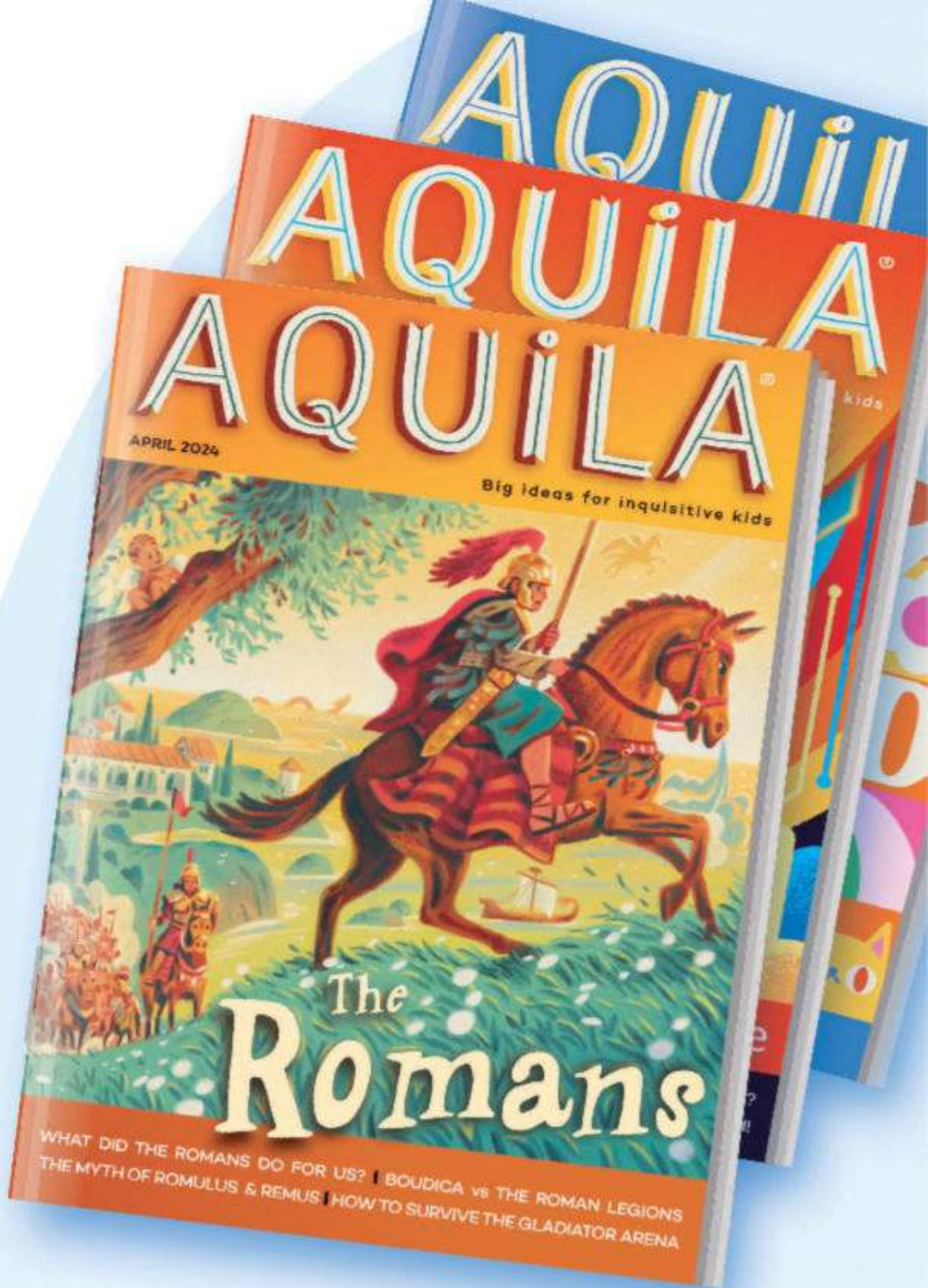
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